REPORT OF THE RATES AND COSTS COMMITTEE

GOVERNMENT OF INDIA

MINISTRY OF IRRIGATION & POWER

REPORT

of

THE RATES & COSTS MMITTEE

Part I

January 1956

GOVERNMENT OF INDIA

MINISTRY OF IRRIGATION AND POWER

(RATES AND COSTS COMMITTEE)

No. RCC/37/56.

Curzon Road Barracks,
New Delhi, the 15th January, 1956.

To

The Secretary to the Govt. of India,
Ministry of Irrigation and Power,
NEW DELHI.

Sir,

With reference to your letter No. DW-III-7 (I), dated the 16th February, 1954, we submit herewith Part I of our Report.

Yours faithfully,

Sd/- (P.C. Agrawal)
Chairman.

Sd/- (M.R. Varadarajan)
Member.

Sd/- (S. Ramier)
Member.

Sd/- (B.D. Nanda)
Member Secretary

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INTRODUCTORY

1.1 The Origin

1.1.1. "The Government of India have been viewing with some concern the large increase in the estimated expenditure of some of the Major River Valley Projects under execution in the country. Special provision has been made for these projects in the Five-Year Plan and periodic increases in the estimated costs, apart from making it difficult to find ways and means of providing additional funds for the completion of such projects, are calculated seriously to affect the implementation of the plan. Under-estimating, due to the absence of adequate information on the rates to be adopted for different items of work seems to be one of the main causes of these mounting estimates. At present there are wide variations between the schedule of rates prevalent in different projects. Government of India, therefore, consider it necessary to evolve a comprehensive standard schedule of rates including detailed analysis of such rates, at least for the major items, which can be used as a basic schedule for all projects. These standard rates can be utilised for examination of future projects after making due allowance for local conditions. The Government of India have accordingly set up a committee of experts to examine the existing rates in the more important projects *viz.* Bhakra-Nangal, D.V.C., Hirakud, Tungabhadra, Lower Bhavani, Malampuzha, Kakrapar, Bhadra, Mayurakshi and Chambal under execution in the country and submit a report to the Government."

[*Extracted from Ministry of Irrigation and Power's No. D.W.* III-7 (*I*), *dated* 16-12-54.]

1.2 The Appointment of the Rates & Costs Committee and its Terms of Reference

1.2.1. Sarvashri P. C. Agrawal, ISE (Retd.), Ex-Chief Engineer, U.P. (Chairman), Raunaq Lal, Deputy Chief Accounts Officer, Bhakra-Nangal Project (Member) and G. G. Dhanak, now Superintending Engineer, Tapi Circle, P.W.D., Bombay (Member-Secretary) were appointed to the Committee on its formation, *vide* Ministry of Irrigation and Power letter No. DW-III-7(I) dated 16th Feb., 1954. The Committee was required to make recommendation on the following terms:—

(*i*) A comprehensive standard schedule of rates for manual as well as machinery work, which can be used as a basic

schedule for all projects with such modifications as may be necessary for zonal consideration ;

(*ii*) Standard analysis of rates for the main items of River Valley Projects estimates which would enable rates being worked out for any project with the help of the basic schedule, after allowing for differences in cost of carriage and other local factors involved ;

(*iii*) The causes which have led to the difference in rates at present prevalent on the various major projects (dams and canal works) ; and

(*iv*) To examine the present P.W.D. forms with a view to suggest modifications which would serve the purpose of better cost accounting on all River Valley Projects.

1.2.2. These Terms of Reference were further amplified by the Government of India, with the concurrence of Comptroller and Auditor General in their letter No. DW-III-22 (108) dated 4th June, 1954 stating that "the Committee will also visit a typical Railway Workshop (Central Railway Workshop, Parel), and after studying the system of maintenance and accounting of stores in force on the Projects, the Railway, and the Electricity Department of the Government of Madras and the procedure on stock control as laid down in B.S.S. 1100—Part 5 by British Standard Institution, and make recommendations on :—

(*i*) Stock account rules to be adopted for both quantity and value of accounts of stores for River Valley Projects ;

(*ii*) Suitable forms for the maintenance of quantity and value accounts of stores ;

(*iii*) procedure for the maintenance of accounts of special tools and plants and machinery and the forms pertaining thereto ; and

(*iv*) rules for placing orders for stores, taking delivery from railway (or other carriages), carriage to godowns, safe custody (including construction of godowns, bins and yards), employment of guards, physical verification, issues, etc., with form such as challans, gate passes etc., for upkeep and custody of stores (including all tools and plants) to guard against thefts, shortages etc., and ensure fixing of responsibility thereof.

1.2.3. In so far as the Terms of Reference of the Committee relating to matters falling within Article 160 of the Constitution are concerned the Committee was deemed to function for and under the Comptroller and Auditor General of India, *vide* Government of India, Ministry of Irrigation and Power letter No. DW. III-22 (108) dated 4th June, 1954. Briefly these terms were :

(*i*) To make suggestions for the introduction of such subsidiary rules or accounts as would ensure a more effective control over the cost of certain items of works ; and

(*ii*) To suggest improvements, *inter alia,* in the system of store accounting as far as possible.

1.2.4. Government further directed that the Committee's recommendations in regard to these matters should be made in self-contained sections of the Report for transmission by the Government of India to the Comptroller and Auditor General of India for such action as he may consider necessary.

1.3. Changes in the Personnel

1.3.1. Shri N. S. Sandhu, Executive Engineer, Stores Division, Bhakra Dam Project, was then appointed as an additional Member of the Committee in view of the extended scope of work outlined in para 1.2.2. The Committee was further strengthened by the inclusion of two more Members namely Shri B.D. Nanda, Consulting Engineer and Ex. Member-Secretary, D.V.C. Enquiry Committee and Shri M. R. Varadarajan, General Manager, Hindustan Construction Co., Ltd., Bombay. They joined the Committee on 18-6-1954 and 18-7-1954 respectively.

1.3.2. Shri G. G. Dhanak was called back by the Bombay Government on the 1st November 1954 and was relieved by Shri B.D. Nanda.

1.3.3. Shri N. S. Sandhu returned to the Bhakra-Nangal Project on the 31st December, 1954, while Shri Raunaq Lal proceeded on two months' leave for reasons of health from 10th January, 1955. He was replaced by Shri S. Ramier, Finance Officer, Ministry of Finance, Government of India.

1.4. Clarification of the Terms of Reference

1.4.1. The Ministry of Irrigation and Power, in their letter No. DW. III-7 (1) dated 5th March, 1954, indicated the main items of work which were to be examined by the Committee for the preparation of standard analysis of rates. These are given below :—

(*a*) Earthwork of all descriptions pertaining to :

1. Dams and Dykes;
2. Excavation in foundation of dams and weirs and canal excavation ;
3. Figures for swell and shrinkage factors in earthwork.

(*b*) Drilling and grouting;

(*c*) Concrete in dams;

(*d*) Shuttering for concrete in dams;

(*e*) Reinforced concrete in ordinary and special structures;

1. Concrete ;
2. Reinforcement ;
3. Shuttering ;

(*f*) Brick Masonry ;
(*g*) Stone Masonry ;
(*h*) Steel Gates ;

1. Crest Gates ;
2. Sluice Gates ;

(*i*) Plinth area rates for buildings ;

1. Temporary ;
2. Permanent.

1.4.2. The Committee had an opportunity to meet Shri Gulzari Lal Nanda, Minister for Irrigation and Power on 25th May, 1954, when the Terms of Reference were discussed at length and further clarified.

1.4.3. The Committee obtained a confirmation from the Ministry that its Terms of Reference did not include an examination of items concerning Power Generation and Transmission.

1.5. Collection of Data

1.5.1. The Committee visited the following places to collect data and acquire first hand knowledge of the local conditions :—

A. River Valley Projects

(1) The Bhakra Nangal	(East Punjab)
(2) The Sarda Hydro-Electric	(Uttar Pradesh)
(3) The Sarda Sagar	(Uttar Pradesh)
(4) The Mayurakshi	(West Bengal)
(5) The D.V.C. Projects :	
(*i*) The Tilaiya	(Bihar)
(*ii*) The Maithon	(Bihar)
(*iii*) The Panchet Hill	(West Bengal)
(*iv*) The Konar	(Bihar)
(*v*) The Durgapur	(West Bengal)
(*vi*) The Bokaro	(Bihar)
(6) The Hirakud	(Orissa)
(7) The Tungabhadra (Andhra)	(Andhra)
(8) The Tungabhadra (Hyderabad)	(Hyderabad)
(9) The Lakhavali	(Mysore)
(10) Vaitarna	(Bombay Corporation)
(11) The Gandhi Sagar	(Madhya Bharat)

(12) The Kotah Barrage (Rajasthan)
(13) The Mata Tila Dam (Uttar Pradesh)

B. Workshops

(1) The Central Tractor Workshop (Delhi)
(2) The Izzatnagar Workshop (Uttar Pradesh)
(3) The Government Workshop (Madras)
(4) The Central Railway Workshop (Bombay)
(5) The Central Workshop, Amritsar (Punjab)

C. Commercial Undertakings

(1) M/s Associated Imports & Exports (Calcutta)
(2) M/s William Jacks Ltd. (Calcutta)
(3) M/s Blackwood Hodge Ltd. (Calcutta)
(4) M/s Tractors (India) Ltd. (Calcutta)
(5) M/s Larson Toubro Ltd. (Bombay)
(6) M/s Voltas Ltd. (Delhi)
(7) M/s Power Sams Ltd. (Bombay)
(8) M/s Hollorith (India) Ltd. (Delhi)

1.5.2. The Committee also took into consideration the recommendations of the following Committees :—

1. Labour Conditions in Building & Construction Industries in India—Ministry of Labour.
2. Report of the Committee of Experts for Building Works—Ministry of Works, Production & Supply.
3. Report of the Environmental Hygiene Committee, October, 1949.
4. Report on the Central Public Works Department and the Central Water & Power Commission—Ministry of Works, Housing & Supply.
5. Report of the Construction Plant and Machinery Committee—Ministry of Irrigation & Power.
6. Report of the Damodar Valley Enquiry Committee—Ministry of Irrigation & Power.
7. Report on the Planning and Management of Building Contracts by Central Council of Works and Buildings, London.
8. Report of the Stores Purchase Committee.

1.5.3. Discussions were also held with several engineers, accounts officers and other well-informed persons in the Engineering Industry.

1.5.4. Questionnaires on matters relating to accounts and stores were issued to a large number of projects and State Organisations and

the opinions received have been considered by us while making our recommendations.

1.5.5. Later, when the Committee during the course of its labours felt that the requisite engineering data was not forthcoming from the projects, it approached Ministry for assistance.

1.5.6. The Ministry of Irrigation and Power *vide* their No. DW-III-221 (108)/5 dated 15th October, 1954, issued to the State Governments and the Project authorities a questionnaire on Rates & Costs along with a number of proformas, drafted by the Committee. The response from the projects, however, was not seen very encouraging. Replies from many of them were not forthcoming for considerable time and we felt that it would not be correct to draw conclusions from incomplete data as it might be the missing one which may be quite important in explaining the variations in prices.

The Committee, thereupon sought permission of the Government to submit an interim Report by the 30th June, 1955, without incorporating information in respect of Term (3). This was granted.

1.5.7. The report was circulated at the Engineers' Seminar at Srinagar (Kashmir). The Engineers and Officers present promised the Minister of Irrigation and Power to send in their comments thereon after a thorough study at home by 15th September 1955.

1.5.8. Very few officers were however able to adhere to their resolve. Due consideration has been given to the comments received and the recommendations amended by us where necessary.

1.6. Our Approach

1.6.1. The projects were furnished with proformas so as to seek information in respect of the direct and indirect expenditure and the break-up of the unit rates into their elements. Only in very few cases we have been able to get the complete information. It is true that the projects had their own difficulties in furnishing the data due largely to their accounts being not in shape to enable them to draw out the required information.

1.6.2. Realising that a single-ready-to-use schedule for the entire country was impracticable and the best that could be offered was the structure of each principal item, we decided to separate the highly variable elements like wages and prices from the constants like output of men and machines, proportions of materials etc., for purposes of the study.

1.6.3. We have on the basis of assumed wages, prices of materials and equipment, etc., mentioned in Chapter 15, worked out analysis of rates for some of the principal items. Adjustments in these item rates

due to variations of time and place should be made in their analyses to derive new rates.

1.6.4. In determining the causes of variation in the prevailing rates over the projects, as required under Term 3, we were faced with innumerable difficulties as the Unit Rates on the projects differed widely in their composition and two projects offered the same conditions of work. Not only did they differ in details but their methods of control and execution, local materials, leads and lifts, etc., were very different. The only way out of this difficulty was to examine the various constituents of each item over the projects and bring out the variations as far as feasible.

1.7. The Layout of the Report

1.7.1. The Report has been divided into two parts to meet the special requirements of our Terms of Reference. Part I is meant for the Ministry of Irrigation and Power and Part 2 for the Comptroller and Auditor General of India. Chapters on Cost Control and Stores, which are of interest to both have been included in both the parts.

1.7.2. Part I comprises 16 Chapters as shown below:—

Chapter 1.	Is the Introduction.
Chapter 2.	Deals with general matters relating to the study of rates and other elements of cost.
Chapter 3.	Deals with the Economics of the Construction Equipment.
Chapter 4.	Deals with Stores Management and Control.
Chapter 5.	Deals with the Control of Cost on Projects.
Chapter 6.	Deals with the outputs and rates of earth-moving machines.
Chapter 7.	Deals with the analyses of Rates of Earthwork by Manual Labour.
Chapter 8.	Deals with the Economics of Transport.
Chapter 9.	Deals with Quarrying and Drilling.
Chapter 10.	Deals with Tunnelling.
Chapter 11.	Deals with Brickwork and the Lining of Canals.
Chapter 12.	Deals with Steel Gates.

1.8. Additional Assignments

1.8.1. At the instance of the Ministry of Irrigation and Power the Committee submitted a 'Paper relating to problems connected with its Terms of Reference' to the Engineers' Seminar at Roorkee, 1954. This paper was circulated to the participants but could not be discussed for lack of time. The Committee was, thereupon, asked to present an Interim Report in its place for discussion at the following Seminar which was done.

1.8.2. The Committee also functioned as Sub-Committee No. 2 of the Engineers' Seminar to examine the report of the Nangal Sub-Committee on Unit Rates for Concrete and Masonry Dams.

1.8.3. The Co-ordination Committee of Engineers was also requested to examine Shri Gupchup's paper on 'Gravity Dams' and make recommendations on the 'Relative Places of Concrete and Masonry' which was duly submitted.

1.8.4. Three meetings were held on the 2nd and 3rd September, 1954, and a number of eminent engineers participated therein. A report on the subject was submitted to the Co-ordination Committee for discussion at the Srinagar Seminar, 1955.

1.8.5. The Committee also participated in the Symposium on Concrete *Vs.* Masonry for construction conducted in Delhi under the auspices of Central Board of Irrigation and Power on 10th November, 1955, and put up recommendations which were unanimously adopted.

The Ministry of Irrigation and Power also gave us a number of other small but important assignments, which are not included in this Report.

CONSTRUCTION COST

2.1. Preliminary Investigations

2.1.1. The expenditure on surveys and investigation of a project is booked under the Head 18 (A) in the first instance. After a project is sanctioned, this expenditure is debited to the item A-Preliminary of the same.

2.1.2. After a project is sanctioned, greater attention is paid to its execution and very often investigations and surveys do not receive the attention they deserve resulting in subsequent changes in design and methods of construction which prove expensive. It would lead to economy and efficiency if projects are taken in hand only after they have been thoroughly investigated.

2.2. Planning Projects

2.2.1. Changes in design for want of proper advance planning have led to considerable excesses in expenditure on a number of projects. The delay and dis-organisation caused thereby, not only add to the immediate cost of the work but they also undermine the general morale of the staff and have a far-reaching effect. It is, therefore, important to undertake planning in advance of construction. As detailed planning takes considerable time, due provision should be made in State and Central budgets for this work and steps should also be taken to encourage Indian experts on planning and design so that we may have to depend less and less in this respect on foreign assistance.

2.3. Project Estimates

2.3.1. On most projects there have been several revisions of estimates for one reason or the other. Only the latest estimates have been adopted by us for our study.

2.4. Divisional Schedule of Rates

2.4.1. The schedules of Rates are prepared in almost all Irrigation Divisions and are supported by the "ANLYSES OF RATES". These rates are used for purposes of estimating, negotiating job work, pricing extra items of contract and for cost control. They are based on current

wages and prices of materials and are revised periodically. Works are usually allotted to piece workers on the basis of these rates. They include direct charges and indirect expenses but are exclusive of departmental overheads.

2.4.2. Enquiries from Public Works Departments of the Centre and the States reveal that their schedules allow for on-costs and contractor's profit from 10 to 15% of the prime cost in the item rates which are applied to small works executed departmentally or by piece workers. For large works, it is usual to invite item rate tenders from contractors who include, in their offer, the cost of the ancilliary services and on-costs including profits. Items rates, however, do not include *pro rata* share of departmental overheads expenses.

2.5. Primary Rates

2.5.1. The divisional schedules of rates cannot be utilised as such for purposes of Cost Control in cases where works are executed departmentally. As the picture is not always clear at the time of framing an estimate whether a work is to be done by contract or the departmental agency, it would be advisable to frame the estimate in such a manner that the item rates do not include share of the indirect services and overheads as dealt with later.

2.6. Division of Construction Cost

2.6.1. When the construction of a project is let out to one or more contractors the contract prices with the addition of departmental overheads would determine the cost of the project within close limits. When the project is being executed by force account, organized by the department itself the outlay on a project would fall in the following categories :—

(*i*) Direct Labour and work charge Establishment.

(*ii*) Materials.

(*iii*) Plant use.

(*iv*) The Burden.

2.7. The Labour Component

2.7.1. The Labour component or the cost of the Labour employed on the work relates only to that form of labour which does the physical work. Such work may be done by unskilled labourers, carpenters, masons, truck drivers, crane and shovel operators and others.

2.7.2. The variation in wages over the projects (Appendix 1) shows at a glance the extent of discrepancy in the wage schedules particularly between the South and the other parts of the country—the wages being on the low side in the former case. This also holds good in the case of the superior engineering personnel.

2.7.3. Labour can be paid either on the basis of output or time. The output or piece-rate method reduces the cost of supervision and simplifies both costing and control of expenditure and is therefore, recommended in preference to time-rate method. Group piece-rate, *i.e.* payment of rate to a group of workers on the basis of their combined output is particularly recommended.

2.7.4. To get the best out of labour, it is necessary that the minimum wage be tied to a minimum output and those who produce more should get more in the same proportion. As a further incentive names of efficient workers should find a place in departmental bulletins and even given token awards in recognition of their services.

2.8. WORKCHARGED ESTABLISHMENT

2.8.1. Workcharged establishment :—Charges under this head comprise salaries of mistries, supervisors, foremen etc., who do not work with their own hands but exercise an immediate control over the quality and output of worker.

2.8.2. Provision under this head varies from 1 to 2%. That for some of the projects is given below :—

Bhakra	1 %
Kotah	2½%
Gandhi Sagar	1½%
Hirakud	2 %
Kakrapar	2 %

2.9. THE MATERIALS COST

2.9.1. Some of the important materials required for River Valley Projects are discussed below :—

2.9.2. Cement :—The issue rates of cement over the various projects are tabulated in the table No. 2.9.2. :—

TABLE 2.9.2.

Rates of Cement over the River Valley Projects

Sl. No.	Name of project	Cement per ton		
		F.O.R.	In Store	Ex. Store
1	2	3	4	5
1	Bhakra	69/-	—	76/-
2	Nangal	82/15	85/3	86/7
3	Sarda Sagar	—	—	100/-
4	Matatila	—	—	100/-
5	Chambal (Raj) Kotah	—	—	105/-
6	Chambal (M.B.) Gandhi Sagar	73/3	94/8/6	99/-/4
7	Konar	—	80/-	84/6
8	Mayurakshi	83/12	—	95/-
9	Hirakud	65/4	80/12	85/-
10	Gangapur	94/10	105/-	108/5
11	Kakrapar	—	—	100/-
12	Vaitarna	87/8	—	100/-
13	Tungabhadra (Andhra)	99/8	103/12	105/-
14	Lower Bhawani	70/10	84/14	89/8
15	Malampuzha	61/4	71/11	72/13
16	Bhakra	90/-	—	100/-
17	Peechi	—	—	130/-
18	Perinchani	82/8	—	130/14

2.10. Steel and Woodwork

2.10.1. The Rates for steel (Table 2.10.3) are Rs. 360/- at Lower Bhawani to Rs. 560/- at Bhakra. This variation is due to purchases of steel having been made at different periods. Any project buying steel now will have to pay another Rs. 100/- or so over the highest price paid a year ago.

2.10.2. Price of timber varies over a long range (Table 2.10.3.) on the various projects depending on their nearness to the source of supply.

2.10.3. The issue rates of steel and timber over the various projects are given in Table 2.10.3.

TABLE 2.10.3.

Issue Rates of Steel and Timber over the River Valley Projects

Sl. No.	Name of Projects (Zone-wise)	Steel per ton	Timber (Teak) per FC	Remarks
1	2	3	4	5
1	Nangal	560/-	—	Rate at site.
2	Chambal (Rajasthan) Kotah	—	12/8	
3	Maithon	500/-	15/8	Issue rates taken from the schedule of rates which is applicable to all the DVC Projects.
4	Panchet Hill			
5	Tilaiya			
6	Durgapur			
7	Konar			
8	Hirakud	460/-	10/-	As per Schedule of rates.
9	Gangapur	—	10/-	—do—
10	Kakrapar	510/-to 483/-	7/ to 9/-	—do—
11	Vaitarna	332/-to 416/-	—	
12	Tungabhadhra (Andhra)	420/-	20/-	—do—
13	Lower Bhawani	360/-	13/-to 17/-	—do—
14	Malampuzha	360/-	12/-to 24/-	—do—
15	Peechi	520/-	19/3	—do—

2.11. P.O.L. Group, Rubber Goods, etc.

2.11.1. The rates of these goods are Manufacturers' Association prices and the variations are small depending mainly on the distance of the project sites from rail-heads and ports of supply.

2.12. Locally Produced Materials

2.12.1. The principal local construction materials in use on projects are building stone, coarse and fine aggregates and their prices vary depending on the method of their manufacture, their proximity to the project where they are to be used, the means of transport etc. The comparison of their prices is discussed elsewhere.

2.13. Basic Schedule of Rates

2.13.1. Project Schedule of rates which should be supported by the analyses of rates should also include the following basic data :—

1. Schedule of wages;
2. Schedule of prices of materials & equipment;
3. Schedule of transport rates.

2.13.2. It is necessary that a basic schedule of wages prevalent at the time of the submission of a project should invariably accompany the estimate to enable the project authorities to evaluate accurately the variations under this head at a future date.

2.13.3. Project estimates should always be supported by a schedule of basic prices of materials on which item rates have been framed as then alone can it be possible to examine the effects of variations in such prices on the total cost.

2.14. Comparison of All-in Rates

2.14.1. For a comparative study the true rate of any item of work is the all-in rate which takes into account all the visible elements and also the invisible burden on that item. Such figures are not kept on any project.

2.14.2. Table 2.14.2. shows indirect expenses and overheads as percentages of the direct cost of the project exclusive of the cost of land and rehabilitation works. A break-up of the burdens between indirect and overheads is given below. Their averages come to 16% and 14% respectively.

TABLE 2.14.2.

Burden as Percentage of Primary Cost for—

A. Dams

Sl. No.	Name of Project	Primary cost of works in Lakhs exclusive of the cost of land and rehabilitation	Burden		Total
			Indirect %age	Over-head %age	%age
1	2	3	4	5	6
1	Gangapur	137	12	32	44
2	Matatila	483	7	8	15
3	Gandhi Sagar	564	11	11	22
4	Mayurakshi	220	9	11	20
5	T.B.P. (Andhra)	478	20	15	35
6	T B.P. (Hyd)	501	24	11	35
7	Bhadra	534	18	17	35
8	Perinchani	36	22	22	44
9	Bhakra	4140	19	27	46
10	Maithon	732	24	18	42
11	Panchet Hill	757	25	15	40
12	Tilaiya	170	18	12	30
13	Konar*	850	5	9	14
14	Vaitarna	548	7	2	9
15	Lower Bhawani	398	13	6	19
16	Malampuzha	169	13	8	21
17	Hirakud	2771	19	11	30
		Average	16	14	30

*Contractors' burden is not included.

TABLE 2.14.2. (Contd.)

B-weirs and Barrages

1	2	3	4	5	6
1	Mayurakshi barrages	218	15	9	24
2	Kotah	261	8	9	17
3	Kakrapar	56	24	21	45
4	Nangal	331	8	9	17
5	Durgapur	344	30	15	45
		Average	17	13	30

C-Canals

1	Sarda Hydel	460	8	11	19
2	Chambal RT. & LT.	1632	5	10	15
3	Mayurakshi canals	578	8	11	19
4	Kakrapar	823	6	7	13
5	Tungabhadra (And.)	922	9	9	18
6	Tungabhadra (Hyd.)	1355	12	8	20
7	Bhadra	566	4	5	9
8	Bhakra	2926	3	10	13
9	Nangal	1018	7	12	19
10	Durgapur	829	10	12	22
11	Lower Bhawani	339	5	6	11
12	Malampuzha	151	5	8	13
13	Hirakud	654	9	11	20
		Average	7	8	15

2.15. Items of Burden

2.15.1. Apart from the direct cost, there are other elements excluding cost of the acquisition of land, which contribute to the total cost of a project. This burden may be classified as under :—

A. Indirect Expenses (Ancillary and Incidental)

1. Buildings, including internal services.
2. Service roads and other communications.
3. Water Supply & Sanitary installation.
4. Electric & Power supply installation & Telegraph, Telephone lines and radio stations.

5. Workmen's compensation.
6. Work-site amenities.
7. Small tools and plant.
8. Laboratory testing.
9. Losses on stock and advances.
10. Maintenance of essential services.
11. Miscellaneous.

B. Overheads (Establishment and Audit)

(a) *Establishment charges, including those for the head office and the field.*

1. Salaries (technical and non-technical) including leave and pensionary charges.
2. Stationery, printing, postage and telephone charges.
3. Staff cars and travelling allowances.
4. Entertainment and publicity.
5. Legal expenses (General).
6. Contingencies.

(b) *Consultants' fees.*

(c) *Audit charges.*

2.15.2. Land compensation including cost of settlement, if any, and abatement of land revenue which form a special subject, have been excluded from our studies. The above items of expense are now dealt with seriatim.

2.16. Provision for Buildings

2.16.1. The financial provision under the head 'Buildings' on the projects generally relates to accommodation for labour, staff, community services, workshops and administrative offices. Housing of labour at site, besides being the responsibility of the project authorities, leads to greater efficiency on the job, minimises absenteeism and introduces among the workers a higher sense of duty. We feel, therefore, that adequate accommodation and public utility services should be provided for all persons engaged on a project.

2.16.2. We observed on some projects that while the higher staff has been provided with accommodation and services on a lavish scale, even the bare necessities of life in this direction have been ignored in the case of labourers. We are, therefore, of the opinion that specific standards of accommodation be laid down for all classes of staff and workers, dependent on the country's economy.

2.16.3. The financial provision under the head 'K-Buildings' on the projects relates to offices, workshops, stores and accommodation for labour and supervisory staff. The following table gives analysis of the provision for different categories of personnel on the Hirakud Dam.

TABLE 2.16.3.

Analysis of Capital Outlay on Buildings (Hirakud Project)

Type of building		Capital outlay			Percentage	
		Permanent Buildings (Lakhs)	Temporary Buildings (Lakhs)	Total (Lakhs)	Individual group	Total cost
Residential	Officers	24·6	0·2	24·8	15·7	10·6
	Staff	74·2	9·2	83·4	52·7	35·7
	Workmen	15·1	2·0	17·1	10·8	7·2
	Services	—	32·9	32·2	20·8	14·2
	Total	113·9	44.3	158·2	1;000	67·7
Non-residential	Officers	7·6	1·2	8·8	11.7	3·8
	Stores	9·4	5·4	14·8	19.7	6·3
	W. Shops	0·6	0·3	0·9	1.3	0·4
	Community Works	23·9	0·6	24·5	32·7	10·6
	Services	—	26·1	26·1	34·7	11·2
	Total	41·5	33·6	75·2	100·0	32·3
Grand Total				233·4		100·0

2.17. The Financial Provision

2.17.1. Construction camp buildings are generally of two types, namely (a) temporary and (b) permanent. The former are required for the duration of the project only and their cost is an indirect expense on the project. The latter are constructed for use of the maintenance staff after the completion of the project.

2.17.2. The percentage provision of buildings in a project would depend on :—

(*i*) type of work ;

(*ii*) duration of the project ;

(*iii*) local availability of housing ;

(*iv*) climatic conditions ;

(*v*) specifications adopted for building construction ; and

(*vi*) construction methods (manual or mechanised).

2.17.3. Buildings should be planned in a way that they could be dismantled and the materials re-used elsewhere. When it is not possible to do so they should be planned for duration of project only with no salvage value.

2.17.4. The following table 2.17.4. gives the percentages of the provision of buildings on the projects on direct cost of works excluding cost of land.

TABLE 2.17.4.

Dams

Sl. No.	Name of Project	Primary cost of Works (Lakhs)	Perma-nent Building (Lakhs)	Tempo-rary Building (Lakhs)	Total (Lakhs)	Per cent
1	2	3	4	5	6	7
1	Gangapur	187		—	12	6·5
2	Matatila	4883	5	8	12	2·4
3	Mayurakshi	220	5	6	11	5·2
4	Tungabhadra (And.)	478	3	41	44	9·2
5	Tungabhadra (Hyd.)	501	1	51	52	9·6
6	Perinchani	36	—	—	7	18·5
7	Bhakra-Nangal	4471	241	67	308	6·9
8	Maithon	732	—	—	83	11·4
9	Panchet Hill	757	—	—	86	11·3
10	Tilaiya	170	—	—	14	8·2
11	Lower Bhawani	398	—	—	25	6·3
12	Malampuzha	169	—	—	16	9·7
13	Hirakud	2771	—	—	198	7·1

Weir and Barrages

Sl. No.	Name of Project	Primary cost of Works (Lakhs)	Perma-nent Building (Lakhs)	Tempo-rary Building (Lakhs)	Total (Lakhs)	Per cent
1	Mayurakshi	218	—	—	17.44	8.0
2	Kakrapar	56	4	4	8	14.1
3	Durgapur	344	9	412	50	14.6

Canals

Sl. No.	Name of Project	Primary cost of Works (Lakhs)	Perma-nent Building (Lakhs)	Tempo-rary Building (Lakhs)	Total (Lakhs)	Per cent
1	Sarda Hydel	450	10	6	16	3.5
2	Chambal Valley Projects	1632	22	25	47	2.9
3	Kakrapar	823	—	—	—	—
4	Mayurakshi	578	—	—	25	4.4
5	Tungabhadra (And.)	922	17	11	28	3.0
6	Tungabhadra (Hyd.)	1355	—	—	46	3.9
7	Bhakra-Nangal	3944	112	42	154	4.0
8	Bhadra	556	5	9	14	2.4
9	Durgapur	829	36	15	51	6.2
10	Lower Bhawani	399	—	—	6	1.8
11	Malampuzha	151	—	—	3	2.2
12	Hirakud	654	—	—	37	5.6

2.18. Building Costs

2.18.1. The plinth area rates for some of the residential buildings constructed on the projects have been tabulated in Appendix 2.

2.19. Roads

2.19.1. Temporary roads have to be constructed in order to get access to various sites of work and constitute an important part of planning. Table 2.19.1. shows provision for roads, railways and trolley lines as a percentage of the total direct cost of the project.

TABLE 2.19.1.

Expense on Service Roads, Railways and Trolley Lines

Sl. No.	Name of Project	Percentage Expense			
		Dams, small up to 5 crore rupees	Dams, large above 5 crore rupees	Weir & Barrages	Canals
1	2	3	4	5	6
1	Gangapur	2·1	—	—	—
2	Sarda Hydel	—	—	—	1·4
3	Matatila	0·8	—	—	—
4	Gandhi Sagar	—	4·2	—	—
5	Mayurakshi	2·3	—	2·62	2·12
6	Tungabhadra (And.)	2·6	—	—	1·3
7	Tungabhadra (Hyd.)	—	2·2	—	—
8	Bhadra	—	4·5	—	—
9	Perinchani	1·1	—	—	—
10	Kotah	—	—	1·5	0·1
11	Kakrapar	—	—	7·1	—
12	Bhakra-Nangal	—	6·9	—	0·1
13	Maithon	—	1·7	—	—
14	Panchet Hill	—	1·2	—	—
15	Durgapur	—	—	3·9	0 002
16	Lower Bhawani	6·0*	—	—	—
17	Malampuzha	—	—	—	—
18	Hirakud	—	6·1	—	0·2

*Includes '0' Miscellaneous.

2.20. Water Supply and Sanitation

2.20.1. Table 2.20.1. shows the expense on this head as percentage of direct cost of works on some of the projects.

TABLE 2.20.1.

Expense on Water Supply Installation and Sanitation

Sl. No.	Name of Project	Percentage Expense			
		Dams, small	Dams, large	Weir & Barrages	Canals
1	2	3	4	5	6
1	Matatila	1·1	—	—	—
2	Gandhi Sagar	—	0·4	—	—
3	Mayurakshi	0·3	—	0·46	—
4	Tungabhadra (And.)	2·2	—	—	—
5	Tungabhadra (Hyd.)	—	4·4	—	—
6	Bhadra	—	1·1*	—	0·5
7	Kotah	—	—	**	0.6
8	Bhakra-Nangal	—	1·7	—	0·04
9	Maithon	—	1·6	—	—
10	Panchet Hill	—	4·3	—	—
11	Durgapur	—	—	0·03	—
12	Lower Bhawani	0·1	—	—	—
13	Hirakud	—	0·6	—	0·1

*Chambal Valley Right & Left Canals.

**Dam—Water Supply only.

2.21. Power, Telephone and Telegraph Lines

2.21.1. The cost of power other than that directly charged to works has to be included under indirect expense. Table 2.21.1. gives a consolidated statement of provision made under this head on some of the projects.

TABLE 2.21.1

Expense on Power Supply and Telephone Lines

Sl. No.	Name of Project	Percentage Expense			
		Dams, small	Dams, large	Weir & Barrages	Canals
1	2	3	4	5	6
1	Sarda Hydel	—	—	—	0·1
2	Ghandhi Sagar	—	—	—	
3	Mayurakshi	0·01	—	2·58	0·54
4	Tungabhadra (And.)	0·8	—	—	—
5	Tungabhadra (Hyd.)	—	1·4	—	0.8
6	Bhakra	—	0·6	—	—
7	Perinchani	0·3	—	—	—
8	Kotah	—	—	—	0·1*
9	Bhakra Nangal	—	0·5	—	0·01
10	Maithon	—	5·4	—	—
11	Panchet Hill	—	2·3	—	—
12	Tilaiya	6·4	—	—	—
13	Durgapur	—	—	5·3	0·2
14	Hirakud	—	0·9	—	0·06

*Chambal Valley Right and Left Canals.

2.22. Workmen's Compensation

2.22.1. Due provision also be made in all estimates for compensation to workers suffering injuries on works. We found that such provision was omitted from most of the projects.

2.23. Working-Site Amenities

2.23.1. We also feel that adequate health and sanitary measures are essential on River Valley Projects. Rules on the subject in force in several States have been examined by us. They are generally on the pattern of those in the C.P.W.D. given in Appendix 3.

2.23.2. C.P.W.D. in their analyses of Scheduled Rates indicate a provision of 1·70% under this head. This is the Contractors' responsibility. Table 2.23.2. shows this provision on several River Valley Projects against the departmental obligation.

TABLE 2.23.2.

Expense on Work-site Amenities

Sl. No.	Name of Project	Percentage Expense			
		Dams, small	Dams, large	Weir & Barrages	Canals
1	2	3	4	5	6
1	Gangapur	1·3	—	—	—
2	Sarda Hydel	—	—	—	0·03
3	Matatila	0·07	—	—	—
4	Gandhi Sagar	—	—	—	0·1
5	Mayurakshi	—	—	0·05	0·04
6	Kotah	—	—	—	
7	Tungabhadra (And.)	—	—	0·3	—
8	Tungabhadra (Hyd.)	—	2·8	—	1·4
9	Bhadra	—	1·6	—	1·5
10	Perinchani	0·06	—	—	—
11	Bhakra-Nangal	—	0·7	—	0·002
12	Kakrapar	—	—	0·3	—
13	Durgapur	—	—	0·4	0·006
14	Malampuzha	1.39	—	—	—

*Chambal Valley Right and Left Canals.

2.24. Small tools and Plant

2.24.1. Expense for small tools and plant is not charged directly to units of work but is added as a percentage charge to the cost of a project. This percentage would depend on the class and the value of the work. The general practice is to charge it at 1 per cent of the cost of the whole project including cost of land. We feel that this needs examination. Table 2.24.1 shows actual percentage expense under this head on direct cost of works of projects. The provision for small tools and plant should be based on direct cost of works.

TABLE 2.24.1.

Expense on Ordinary Tools and Plant

Sl. No.	Name of Project	Percentage Expense			
		Dams, small	Dams, large	Weir & Barrages	Canals
1	2	3	4	5	6
1	Gangapur	3·6	—	—	—
2	Sarda Hydel	—	—	—	0·9
3	Matatila	2·7	—	—	0·4
4	Gandhi Sagar	—	0·9	—	—
5	Mayurakshi	0·3	—	1·03	1·23
6	Tungabhadra (Andhra)	—	1·5	—	0·7
7	Tungabhadra (Hyderabad)	—	—	—	6·1
8	Bhadra	—	0·9	—	—
9	Perinchani	2·1	—	—	—
10	Kakrapar	—	—	1·2	0·7
11	Bhakra-Nangal	—	2·0	—	1·0
12	Maithon	—	2·3	—	—
13	Panchet Hill	—	2·9	—	—
14	Tilaiya	2·1	—	—	—
15	Durgapur	—	—	3·3	3·1
16	Lower Bhawani	0·8	—	—	1·3
17	Malampuzha	2·3	—	—	2·5
18	Hirakud	—	1·3	—	1·1

2.25. Laboratory and Testing Charges

2.25.1. There is a small expense on account of laboratory and testing equipment and organisation on the projects.

2.26. Losses on Stock and Advances

2.26.1. The value of stores held on 31.3.1954 at four large projects are given below and it can be expected that some losses would occur.

		(Rs. in lakhs)
(1)	Bhakra	508
(2)	D.V.C. Projects	435
(3)	Hirakud	436
(4)	Tungabhadra	203

2.26.2. Table 2.26.2. shows provision under this head in the project estimates. It is likely, however, that the actual percentages should be different and higher in most cases.

TABLE 2.26.2.

Losses on Stock and Advances

(Estimated figures)

Sl. No.	Name of Project	Percentage Expense			
		Dams, small	Dams, large	Weir & Barrages	Canals
1	2	3	4	5	6
1	Sarda Hydel	—	—	—	0·7
2	Kotah	—	—	1·5*	—
3	Gandhi Sagar	—	0·2	—	0·3
4	Kakrapar	—	—	0·2	—
5	Tungabhadra (And.)	0·5	—	—	0·1
6	Tungabhadra (Hyd.)	—	2·6	—	—
7	Bhakra	—	0·1	—	0·1
8	Maithon	—	1·3	—	—
9	Hirakud	—	0·4	—	0·3

*Chambal Valley Right and Left Canals.

2.26.3. Losses may also be due to purchases of faulty goods, wastage in cutting up, bad workmanship, drying of volatile materials, leakage of liquids and gases etc.

2.27. Maintenance

2.27.1. Table 2.27.1. shows figures for cost of maintenance of buildings and roads as percentage of the direct costs on various projects :—

TABLE 2.27.1.

Expense on 'P-Maintenance'

Sl. No.	Name of Project	Percentage Expense			
		Dams, small	Dams, large	Weir & Barrages	Canals
1	2	3	4	5	6
1	Gangapur	1.9	—	—	—
2	Sarda Hydel	—	—	—	0.6
3	Kotah	—	—	1.2*	0.3
4	Gandhisagar	—	2.0	—	—
5	Mayurakshi	0.1	—	—	—
6	Tungabhadra (Hyd.)	—	0.3	—	0.1
7	Bhakra-Nangal	—	2.0	—	0.9
8	Maithon	—	1.2	—	—
9	Panchet Hill	—	2.2	—	—
10	Tilaiya	1.2	—	—	—
11	Durgapur	—	—	2.0	0.6
12	Lower Bhawani	—	—	—	0.7
13	Malampuzha	0.1	—	—	—

*Chambal Valley Right and Left canals.

2.28. Miscellaneous

2.28.1. Table 2.28.1. gives an account of expense, which is not debitable to any of the above heads and is an indirect expense on some of the projects.

TABLE 2.28.1.

Miscellaneous Expenses

Sl. No.	Name of Project	Percentage Expense			
		Dams, small up to 5 crore rupees	Dams, large above 5 crore rupees	Weir & Barrages	Canals
1	Sarda Hydel	—	—	—	0.6
2	Kotah	—	—	0.8	—
3	Mayurakshi	—	—	0.08	—
4	Tungabhadra (Andh.)	0.4	—	—	1.2
5	Tungabhadra (Hyd.)	—	0.1	—	—
6	Bhadra	—	3.3	—	—
7	Perinchani	0.1	—	—	—
8	Bhakra-Nangal	—	0.003	—	—
9	Maithon	—	0.1	—	—
10	Durgapur	—	—	—	0.02
11	Lower Bhawani	—	—	—	1.1
12	Hirakud	—	—	—	0.04

2.29. Establishment Overheads

2.29.1. Table 2.29.1. gives the establishment expense on various projects.

2.30. Contingencies

2.30.1. A provision for contingencies at 5 per cent is made when a project estimate is put up for the administrative sanction to cover the cost of unforeseen items, and incidental expenses of a miscellaneous character.

TABLE 2.29.1.

Expense on Establishment and Overheads

Sl. No.	Name of Project	Percentage Expense			
		Dams, small up to 5 crore rupees	Dams, large above 5 crore rupees	Weir & Barrages	Canals
1	Gangapur	31.3	—	—	—
2	Matatila	6.2	—	—	—
3	Sarda Hydel	—	—	—	9.5
4	Gandhisagar	—	3.4	— } 7.3*	—
5	Kotah	—	—		9.1
6	Mayurakshi	8.8	—	7.8	9.3
7	Kakrapar	—	—	21.6	11.7
8	Tungabhadra (Andh.)	13.3	—	—	7.9
9	Tungabhadra (Hyd.)	—	10.0	—	16.3
10	Bhadra	—	17.0	—	5.0
11	Perinchani	22.1	—	—	—
12	Bhakra-Nangal	—	23.2	—	11.1
13	Maithon	—	16.8	—	—
14	Panchet Hill	—	14.2	—	—
15	Tilaiya	14.4	—	—	—
16	Durgapur	—	—	14.8	11.3
17	Lower Bhawani	4.8	—	—	4.4
18	Malampuzha	6.7	—	—	7.5
19	Hirakud	—	9.7	—	10.5

*Chambal Valley Right and Left canals.

The present provision of 5 per cent *ad valorem* irrespective of the magnitude of the work is very much on the high side in the case of large projects taken in hand after prolonged investigations and planning. We, therefore, recommend the following scales instead:—

1. For works costing upto 5 crores : 5%.

2. For works costing above Rs. 5 crores but less than Rs. 15 crores : 4 per cent with a minimum of Rs. 25 lakhs.

3. For works costing above Rs. 15 crores but less than Rs. 25 crores: 3 per cent with a minimum of Rs. 60 lakhs.

4. For works costing above Rs. 25 crores but less than Rs. 40 crores : 2½ per cent with a minimum of Rs. 75 lakhs.

5. For works costing above Rs. 40 crores : Rs. 1 crore fixed.

NOTE—The cost of work should be exclusive of contingencies.

2.30.2. It is also a common practice to make a full provision of contingencies at 5 per cent in the case of revised estimates even though submittted in advanced stages of construction. When very little remains, unforeseen provision under this item should be suitably curtailed and may even be eliminated.

2.31. Consultants' Fees

2.31.1. Even on important projects no provision is made for payment of fees to consultants which sometimes becomes necessary during execution. No precise scale can be laid down for it but a fraction of a per cent of the cost of the project should meet the requirements generally. Table 2.31.1. shows expenditure under this on some of the projects.

TABLE 2.31.1.

Expense on Consultants' Fees

Sl. No.	Name of Project	Percentage Expense			
		Dams, small up to 5 crore rupees	Dams, large above 5 crore rupees	Weir and Barrages	Canals
1	Matatila	0.1	—	—	—
2	Sarda Hydel	—	—	—	0.02
3	Gandhisagar	—	0.2	—*	—
4	Kotah	—	—	0.2*	0.06
5	Bhakra-Nangal	—	1.7	—	—
6	Maithon	—	1.2	—	—
7	Panchet Hill	—	0.3	—	—
8	Hirakud	—	0.03	—	—

*Chambal Valley Right and Left canals.

2.32. AUDIT CHARGES

2.32.1. Table 2.32.1. gives figures for percentage charges of audit and accounts to the direct charges on the various projects.

TABLE 2.32.1.

Expense on Audit and Accounts

Sl. No.	Name of Project	Percentage Expense			
		Dams, small up to 5 crore rupees	Dams, large above 5 crore rupees	Weir and Barrages	Canals
1	Gangapur	1.2	—	—	—
2	Sarda Hydel	—	—	—	—
3	Matatila	1.1	—	—	—
4	Gandhisagar	—	1.4	—	—
5	Kotah	—	—	1.2*	—
6	Mayurakshi	2.4	—	1.1	1.4
7	Kakrapar	—	—	—	—
8	Tungabhadra (Andh.)	1.8	—	—	—
9	Tungabhadra (Hyd.)	—	0.6	—	—
10	Bhakra-Nangal	—	0.7	—	—
11	Maithon	—	0.4	—	—
12	Panchet Hill	—	0.4	—	—
13	Tilaiya	3.8	—	—	—
14	Durgapur	—	—	—	—
15	Lower Bhawani	0.9	—	—	—
16	Malampuzha	1.1	—	—	—
17	Hirakud	—	1.3	—	—

*Chambal Valley Right and Left canals.

2.33. THE OVERALL BURDEN

2.33.1. Whenever rates of items over different projects have to be compared, it would be necessary to add cumulative burden on primary rates. Burden will be a fixed percentage charge for most of the items of expense but may be variable percentage in some cases such as an indirect wage bill of establishment which will be inversely proportional to the variation of output on estimated production of men and machines.

2.33.2. In the case of construction works the burden on 'Prime Cost Base', which is likely to average out the peculiar variations in the nature of item of burden, should be used in preference to any other base such as cost of labour, materials, etc.

2.33.3. The overall burden is substantial and we feel that economy should be possible under this head, wherever possible.

2.34. Responsibility for Indirect Services

2.34.1. When a large project is carried out under a series of contracts, the responsibility for providing indirect services for the proper execution of works is shared among them and it can be understood that either services would not be adequately provided for or there may be waste due to multiplicity of provisions by several piece rate workers, although the latter has perhaps never occurred. It would, therefore, be only right that the provision of indirect works should be separately made in each project. Only where the whole project is offered to a single agency for execution, this provision may form an invisible part of the contractors' bid items.

2.35. Conditions of Payment on Works

2.35.1. The provisions for interim payment on account of work or advances and those for the release of part of the retention and final payment deserve a very careful consideration, in framing the Conditions of Contracts. These arrangements intimately affect both the Government and the contractor. The Government must balance the advantages of paying promptly against fewer and larger payments needing contractors with larger financial resources which may affect the bids.

2.36. Contractors' Overheads and Profits

2.36.1. *Overheads*—An allowance of 10 per cent would be adequate for the contractor's actual expense on supervisory establishment, field office and share of head office charges, travelling expenses, publicity, interest and insurance of damage to plant and injury to labour.

2.36.2. *Profits*—We believe that in normal circumstances an allowance of 10 per cent of the prime cost as contractor's profit is reasonable.

2.37. Rates of Expenditure on Preliminary Survey

2.37.1. The rates of expenditure on preliminary survey are highly variable, but those stipulated by the Survey of India and given below, may be treated as a guide (Table 2.37.1.).

TABLE 2.37.1.

1.	Air mapping.	Rs. -/10/8	per acre
2.	Detailed ground contour survey.	Rs. 1/10/-	-do-
3.	Land use survey and planning	Rs. -/12/6	-do-
4.	Forest Survey.	Rs. -/10/6	-do-
5.	Upland irrigation survey including drilling, test pits, canal layouts, dam design.	Rs. 1/8/-	-do-

ECONOMICS OF CONSTRUCTION EQUIPMENT

3.1. Construction Methods (Manual *versus* Mechanical)

3.1.1. Changes in living and social conditions at home and abroad have raised the labour wages and they are still rising. In view of the present tempo of works which has created a large demand for construction labour and also due to rise in their living standards, we feel that a reduction in labour rates is hardly possible.

3.1.2. While considering the economy of Manual *versus* Machines the following points should be taken into account :—

(*i*) Expense on free transport for labour from their villages to project sites and sometimes railway or bus fares back on completion of the works;

(*ii*) Adequate amenities in future;

(*iii*) General inaptitude of labour for hard work.

A comparison of rates of excavation both by manual and mechanical agencies has been dealt with elsewhere in the Report. It may be, however, stated here that for leads exceeding 300′ and lifts exceeding 20′ the execution of earthwork by manual labour is generally uneconomical.

3.1.3. Factors which militate against the use of machines in this country are :—

(*i*) that they are almost invariably made in foreign countries and their use, therefore, tends to deplete reserves of foreign currency;

(*ii*) that there is a tendency on the part of the agents not to have adequate stocks of spare parts in India; and

(*iii*) that there is a lack of planning in obtaining spares from abroad, even when urgently needed, resulting in enormous losses of time and money on projects.

3.1.4. Machines become, more or less, indispensable for places, which are unhealthy, inaccessible, or where time is an important factor. They are expensive and the greatest care should be exercised in their acquisition. Some of the arguments against the use of machines would cease to apply when construction equipment industry is established in this country as recommended by us in para 3.2.4.

3.2. Manufacture of Construction Equipment

3.2.1. We do not share the Construction Plant and Machinery Committee's pessimism in regard to the feasibility of manufacturing Construction equipment in India. They say that all the major construction projects in India have either been completed or are nearing completion and that the future projects will be either small or medium sized. This is not a correct appraisal of the present position. It may

be true that some of the big dams would be completed in the next few years but they are not going to be the last of their class. The country is so large and the possibilities of development so vast that many large works shall have to be built in future.

3.2.2. That we do not possess the "know-how" of the construction plant industry was until lately true of so many other industries which have since been successfully established. There are ways and means of getting all the "know-how" and we can adopt them in this case also. Construction machinery is fairly simple and if the country can manufacture locomotives, aeroplanes and machine tools, there is no reason why we cannot produce construction equipment.

3.2.3. The Plant and Machinery Committee has recommended that we should make a start with only one or two principal items of equipment on the major side and confine our attention mainly to minor pieces of equipment like 7/10 cft. capacity concrete mixers, tippers, rooters, sheep-foot rollers, etc. While we agree that we should standardise the sizes of equipment into as few items as possible, it would be a mistake to tackle only the minor items of work, as this will not solve the problem.

3.2.4. Our recommendation, therefore, is to concentrate on items of equipment in general demand, standardise their designs and sizes, and go in for their manufacture in right earnest, in co-operation between the public and private sectors.

3.3. Standardisation of Equipment and Spares

3.3.1. In the case of plant selection, full consideration should be given to the availability of spare parts and extent of the need for stocking them to ensure adequate supply of such parts on the job at all times. This brings up the question of the standardisation of equipment. A committee of the Government of India is already looking into this matter. We recommend that this Committee should also go into the standardisation of spares. We lay stress on this point because the prices of standard parts purchased from the manufacturers of parts would be very much lower than those charged by the suppliers of the equipment.

3.4. Capital Outlay

3.4.1. The capital outlay on construction equipment on a project varies from 10 to 30 per cent of the total cost. This percentage is likely to go up in future with the increase in the mechanisation of construction methods. It is imperative that extreme care should be exercised in the selection of various units and as far as possible accurate provision for their depreciation, major repairs and overhauls and salvage value should be made.

TABLE 3.4.1.

Capital Outlay on Construction Equipment on Projects

Sl. No.	Name of Projects	Primary cost of Works (lakhs) including 'Q' Spl. T. & P. provision	'Q' Spl. Tools & Plant Provision (lakhs)	'Q' Spl. Tools & Plant %	Remarks
1	2	3	4	5	6
1	Bhakra Nangal	6009.03	1542.54	25.6	Exclusive
2	Matatila	487.49	109.97	16.0	of salvage
3	Gandhisagar	577.41	35.00	6.06	value

TABLE 3.4.1.—contd.

1	2	3	4	5	5
4	Maithon	746.21	226.00	30.29	Exclusive of salvage value
5	Panchet	806.68	195.20	24.20	
6	Tilaiya	184.76	52.60	28.47	
7	Mayurakshi	228.11	28.58	12.50	
8	Hirakud	3424.94	1139.06	33.25	
9	Gangapur	213.32	71.49	33.5	
10	Tungabhadra (Andh.)	505.69	76.00	15.05	
11	Tungabhadra (Hyd.)	519.05	90.00	17.40	
12	Bhadra	554.11	52.50	9.50	
13	Lower Bhawani	464.24	144.00	31.00	
14	Malampuzha	153.78	24.20	15.75	
	B. Weir & Barrages				
1	Kotah	275.08	40.0	14.54	
2	Durgapur	373.10	81.74	21.91	
3	Kakrapar	60.63	—	—	
	C. Canals				
1	Bhakra Nangal	4563.40	442.87	9.70	
2	Sarda Hydel Scheme	460.09	82.47	19.00	
3	Chambal Rt. & Lt.	1692.15	142.54	8.42	
4	Tungabhadra (Andh.)	964.38	103.00	10.7	
5	Bhadra	565.78	20.97	3.70	
6	Lower Bhawani	346.10	25.00	7.23	
7	Malampuzha	139.27	9.50	6.80	

3.4.2. A reasonably accurate forecast of the number of years the equipment is likely to be employed on the project, the number of hours it could be worked per year and the estimated expense on its major repairs and overhaul for the period and its residual or salvage value (if any), can be made at the outset. A schedule of basic use-rates can then be worked out by adding the estimated cost of running costs per hour viz : the cost of consumables, labour and field maintenance, to the rate of depreciation and major repairs and overhauls per hour. With use-rates' schedule and production tables, estimates of working cost with various plant combinations can be drawn up.

3.5. Determination of Life of Equipment

3.5.1. We concede that no authoritative life schedule of Construction machinery so far exists in this country and so in its absence our River Valley projects authorities have adopted hypothetical life figures which are quite often in excess of the standard lives recognised by standard institutions in U.S.A. and other foreign countries.

3.5.2. The economic lives of machines in years and hours adopted by the foreign authorities and that adopted on our projects have been tabulated in Tables 3.5.2. (i), (ii) 3.5.2. (iii) respectively.

TABLE

Statement of Life of Rated Equipment in Years & Hours

Sl. No.	Equipment	A.G.C. Schedule		U.S.B.R. Bulletin	U.S.B.R. 'F' Bulletin		T.V.A. Schedule
		Years	Operating shift hours	Years	Operating shift hours	Years	Working hours
1	2	3	4	5	6	7	8
1	Air Compressors—Diesel	4·5	4,880—6,000	4.5	4,800-6,000	—	10,000
2	Batching Plant	4·6	4,800—7,200	4.	4,800	—	50% of cost to project
3	Core-drilling machines	3	4,200	3	4,200	3	6,000
4	Concrete Buckets	5	6,000	5	6,000	5	5·6 to 8·3 yrs.
5	Cranes-Crawler:						
	(a) Upto 3 tons	4	6,400	—	—	5	10,000
	(b) 3 to 10 ,,	5	8,000	5	8,000	5	12,000
	(c) Over 25 ,,	7·75	10,850	8	11,200	9	20,000
6	Cranes (Truck-Mounted):						
	(a) Upto 6 tons	4	6,400	—	—	—	18,000
	(b) Upto 15 ,,	5	8,000	4	7,200	—	20,000
	(c) Above 15 ,,	6	8,400	4	7,200	—	—
7	Crushers—						
	(a) Jaw	6	7,200	6	7,200	10	—
	(b) Gyratory	10	12,000	—	—	10	40% of cost to project
	(c) Cone.	10	12,000	—	—	10	—
8	Excavators—Crawlers:						
	(i) Diesel						
	(a) Upto $\frac{3}{4}$ Cyd.	4	7,200	4.5	9,000	—	10,000
	(b) Upto 1 ,,	4·56	7,200—9,520	5.5	9,360	—	12,000
	(c) Upto $2\frac{1}{2}$,,	5·6—6·25	8,960—10,000	6.0	9,600	—	15,000
	(d) Above $2\frac{1}{2}$,,	7·1	10,650	6.0	9,600	-	15,000
	(ii) Electrically operated	5·10	7,000—14,000	6.10	9,600—16,000	5 to 10	20,000
9	Graders	5	8,000	5	8,000	4 to 8	12,000

3.5.2. (i)

Adopted by Various Authorities for Depreciation.

D.C.& S.A. Bulletin		C.C.A. Bulletin		S.C.E.F. Bulletin	New-zealand	Estimating by S.Geddes		C.P. & M.C. Report
Years	Useful hours	Years	Operatings hrs. maximum	Years	Years	Years	Working hours	Plant hours
9	10	11	12	13	14	15	16	17
—	—	6·25-7	12,500—14,000	—	—	5	8,000	8,000
—	—	5	7,500	5	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	7	12,250	—	—	—	—	—
5	10,000	9	18,000	—	—	8	12,000	—
9	18,000	9	18,000	—	—	8	12,000	—
12	24,000	9	18,000	—	—	8	12,000	—
—	—	6·25	14,060	—	—	—	—	9,000
—	—	7	15,750	—	—	—	—	10,000
—	—	7	15,750	—	—	—	—	12,000
—	—	6.25-7	10,940—12,250	—	—	—	—	—
—	—	10	17,500	—	—	—	—	—
—	—	—	—	—	—	—	—	—
5	10,000	7	15,750	—	6·66 @15%	5	9,000	9,000
6	12,000	7	15,750	—	6·66	5	9,000	10,000
8	16,000	8·33	16,700	—	6·66	5	9,000	12,000
8	16,000	8·33	16,700	—	6·66	5	9,000	12,000
—	—	—	—	—	—	—	—	—
—	—	5	7,500	—	6·55 @15%	—	—	10,000

TABLE

1	2	3	4	5	6	7	8
10	Loaders	5	6,000	5	6,000	5-6	15,000
11	Locomotives—						
	Diesel	6—8·3	9,600—13,280	—	—	10	12,000
12	Mixers Concrete						
	(a) Less than 1 Cyd.	3	4,800	3	4,800	6	6,000
	(b) More than 1 ,,	4	6,400	4	4,800	8	6,000
13	Rollers—Road :						
	(a) Diesel	7	11,200	7	11,200	—	10,000
	(b) Gasoline	7	11,200	7	11,200	10	10,000
	(c) Steam	—	—	—	—	10	10,000
14	Scrapers—						
	(i) Motorised :						
	(a) Upto 10 Cyds.	4·5	6,400—8,000	—	—	—	15,000
	(b) Above 10 ,,	5	8,000	4	5,600	—	15,000
	(ii) Towed	3—4	4,200—5,600	4·5	6,400—8,000	—	15,000
15	Tracters—						
	(i) Crawlers :						
	(a) Upto 89 B.H.P.	4—5	7,200—8,000	3—4	4,200—5,600	—	8,000
	(b) Above 89 ,,	5	8,000	4	5,600	—	8,000
	(ii) Wheeled :						
	(a) Upto 40 B.H.P.	3·3—4	6,000—7,200	3.3	6,000	—	—
	(b) Above 40 ,,	4—5	7,200 8,000	4	6,400	—	—
16	Trucks:						
	(a) Diesel	5	8,000	4	7,200	5—8	—
	(b) Gasoline	—	—	3—5	5,400—8,000	5—8	—
17	Trucks—Dumpers :						
	(a) Rear Dump	5	8,000	5	8,000	—	8,000—12,000
	(b) Bottom Dump	5	8,000	4	5,600	—	15,000
18	Well drilling machines 5"—6"	5	8,000	—	—	10	—

Reference :—

1. A.G.C. Schedule :—Associated general Contractors of America Schedule of Equip.
2. U.S.B.R. Schedule :—United States Department of the Interior Bureau of Reclama
3. U.S.B.R. 'F' Bulletin :—U.S. Bureau of Internal Revenue, Income-tax 'F' Bulletin.
4. T.V.A. Note :—"Procedure for Equipment Transfer Evaluation" by George K. Leonard
5. PC&SA Bulletin :—Power Crane and Shovel Association, USA Technical Bulletin.
6. Canadian Construction Association Bulletin.
7. S.C.E.F. Bulletin :—Society of Civil Engineers of France Bulletin.
8. "Estimating" by S. Geddes :—"Estimating for Building & Civil Engineering Works"
9. CP&MC Report :—Plant and Machinery Committee Report.

3.5.2. (i)—contd.

9	10	11	12	13	14	15	16	17
—	—	—	—	—	—	—	—	—
—	—	6·25—9	12,500—18,000	—	—	10	15,000	—
—	—	3	6,000	—	—	7	12,600	—
—	—	5	10,000	—	—	7	12,600	—
—	—	8·33	12,500	—	5@20%	8	14,400	
—	—	8·33	12,500	—	5@20%	—	—	—
—	—	12·5	18,750	—	5@20%	12	21,600	—
—	—	6·25	10,940	5	—	—	—	9,000
—	—	6·25	10,940	5	—	—	—	10,000
—	—	—	—	5	—	—	—	10,000
—	—	6·25	12,500	5	—	5	9,000	9,000
—	—	6·25	12,500	5	—	5	9,000	10,000
—	—	5	11,250	5	—	5	9,000	—
—	—	5—6·25	11,250—12,500	5	—	5	9,000	10,000
—	—	5	11,250	—	—	5	11,000	—
—	—	5	11,250	—	—	5	11,000	—
—	—	6·25—·7	14,060—15,750	4	—	4	8,000	10,000
—	—							
—	—	6·25—·7	14,060—15,750	4	—	4	8,000	10,000
—	—	7	12,250	—	—	—	—	—

ment ownership expense.
tion Schedule of Equipment Ownership Expense.

Chief Construction Engineer, Knawike, U.S.A.
No. 2, Operating Cost, Guide.

by Spence Geddes.

TABLE 3.5.2 (*ii*)

Statement of Depreciation Rate per Month of Non-Rated Equipment

Sl. No.	Equipment	A. G. C. Schedule	T. V. A. Schedule	U. S. B. R. Bulletin	C. C. A. Bulletin
1	2	3	4	5	6
1	Air Compressors : Stationary	3·33%	1%	...	2—2·3%
2	Bins	3—4%	50% of cost to project	30Mths.	2%
3	Boats	...	3%	...	...
4	Boilers	2·33%	1·5%	...	1·7% to 2%
5	Cableway	4—5·5%	50% of cost to project	...	...
6	Engines :				
	(*i*) Diesel upto—100 HP	1·7%	...	59Mths.	1·5%
	100 to 500 HP	1·4%	...	59 "	1·25%
	(*ii*) Gasoline				
	Upto 10 HP	3%	...	46 "	2·5%
	11 to 20 HP	2%	...	42 "	2%
	20 to 30 HP	2%	...	49 "	1·8%
	Above 30 HP	1·9%	...	59 "	1·7%
	Electric Light Plant:				
	(*i*) Diesel				
	Upto 10 KW	2·5%	...	56 "	1·7%
	Upto 25 KW	2·5%	...	56 "	2%
	Above 25 KW	2·5%	...	56 "	1·8%
	(*ii*) Gasoline				
	Upto 10 KW	2·5%	...	35 "	2%
	Upto 25 KW	2·5%	...	49 "	2%
	Above 25 KW	2·5%	...	56 "	1·8%
8	Hoists : Air	1·6%	3%	40 "	1·7%
	Chain	1·6%	50% Cost to Project	80 "	2·5%
	Electric	1·6%	2%	56 "	1·5%
	Gasoline Upto 10 HP	2·5%	...	40 "	2·5%
	Above 10 HP	2%	...	48 "	2—1·5%
9	Pile Hammers Single Acting	3%	1½%	...	2·3%
	Double Acting	5·5—3%	1½%	...	2·3%

TABLE 3.5.2 (*ii*)—contd.

Sl. No.	Equipment	A. G. C. Schedule	T. V. A. Schedule	U. S. B. R. Bulletin	C. C. A. Bulletin
1	2	3	4	5	6
10	Pneumatic Tools :				
	Drifters	4%	...	24 Mths.	6·7%
	Jackhammers	4·5%	3 %	18 "	6·7%
	Pumps	5·5%	3%	...	6·6%
	Vibrators	4·7%	3%	21 "	5·5%
	Wagon drills	2%	3%	24 "	2%
11	Pumps :				
	Grout	...	2%	35 "	4%
	Pump etc.	4%	3%	24—30"	3%
	Centrifugal	3·3%	1½—3%	30 "	2—2·6%
12	Rollers:				
	Sheeps foot	3—4%	1½%	32 "	2·3%
13	Sand-Plant Outfit	3%	1½%	...	...
14	Welding Machines	2·5%	...	40 "	1·75—2%

Reference:—

1. A. C. C. Schedule : Associated General Contractors of America Schedule of Equipment Ownership Expense.
2. T. V. A. Schedule : Procedure of Equipment Transfer Evaluation by George K. Leonend, Chief Const. Engineer, T. V. A.
3. U. S. B. R. Bulletin: United States Department of the Interior Bureau of Reclamation Schedule of Equipment Ownership Expense.
4. C. C. A. Bulletin : Canadian Construction Association Bulletin.

TABLE

Statement of Life Hours

Sl. No.	Equipments			Bhakra	Nangal
1	2			3	4
1	Air Compressors Diesel	...	...	8,000	...
2	Batching & Mixing Plant	...	...	...	...
3	Core-drilling Machines	...	...	...	12,000
4	Cranes—Crawler:	...	...		
	a. Under 3 Tons	...	...	...	...
	b. 3 to 10 Tons	...	...	...	...
	c. Over 25 Tons	...	...	15,000	...
5	Cranes—Truck-Mounted:				
	a. Under 6 Tons	...	...	...	...
	b. Under 15 Tons	...	...	...	...
	c. Above 15 Tons	...	...	12,000	...
6	Crushers:				
	a. Jaw	...	...	...	...
	b. Gyratory	...	...	...	...
	c. Cone	...	...	10,000	...
7	Excavators—Crawlers:				
	(i) Diesel—				
	Up to $\frac{3}{4}$ C yd.	...	...	17,000	20,000
	Up to $1\frac{1}{2}$ C yd.	...	...	17,000	15,000
	Up to $2\frac{1}{2}$ C yd.	...	...	22,000	30,000
	Up to $3\frac{1}{2}$ C yd.	...	...	22,000	30,000
	(ii) Electrical	...	...	33,000	...
8	Graders	...	...	12,000	8,000
9	Loaders	...	...	...	...
10	Locomotives. Diesel	...	...	20,000	...
11	Mixers: Less than 1 C yd.	...	...	8,000	...
	More than 1 C yd,	...	...	8,000	...
12	Roolers Road:	...			
	a. Diesel	...	...	...	...
	b. Gasoline	...	...	...	...
	c. Steam	...	...	...	...
13	Scrapers:	...			
	a. Motorised—				
	(i) Up to 10 C yds.	...	...	...	15,000
	(ii) Above 10 C yds.	...	...	...	15,000
	b. Towed	...	...	...	...
14	Tractors:				
	(i) Craulers—				
	a. Up to 89 BHP	...	...	12,000	12,000
	b. Above 89 BHP	...	...	12,000	12,000
	(ii) Wheeled	...	...	...	...
	a. Up to 40 BHP	...	...	...	...
	b. Above 40 BHP	...	...	...	...
15	(i) Trucks				
	(a) Diesel	...	...	8,000	...
	(b) Petrol	...	...	8,000	...
	(ii) Dumper Trucks:				
	(a) Rear Dump	...	...	17,000—19,000	10000—12000
	(b) Bottom Dump	...	...	...	...

3.5.2. *(iii)*

adopted by Projects

D.V.C.	Hirakud	Tungabhadra (Hyderabad)	Tungabhadra (Andhra)	Gangapur
5	6	7	8	9
Years				
...	...	...	...	10,000
...	...	...	...	...
...	...	...	...	...
5	...	...	...	...
5	...	...	...	...
9-12	...	...	...	...
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
10	...	...	...	...
10	...	...	...	...
...	...	...	...	10,000
6	...	...	...	10,000
8	16,000	20,000	18000—24000	15,000
8	16,000	20,000	18000—24000	15,000
...	...	...	...	...
5	7,000	...	...	10,000
5	12,000	...	...	10,000
10	...	...	...	...
3—4	...	...	...	...
5	...	...	...	...
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
5	...	10,000	12,000	10,000
5	8,000	10,000	12,000—	10,000
...	...	...	24,000	...
4	7,000	20,000	10,000	10,000
5	7,000	20,000	10,000	10,000
5	7,000	...	...	...
5	7,000	...	...	...
5—8	...	...	...	...
5—8	...	...	...	...
4—5	10,000	10,000	10,000	10,000
5	10.000	...	10000-12000	10,000

3.6. Depreciation

3.6.1. *Its relationship with life of equipment*—Depreciation usually refers to the process of charging into unit rates a fair amount of the "first cost" of construction plant to cover the wear and tear obsolescence and loss in value. It practically means that the difference between the first cost and re-sale or salvage value must be charged to the work.

3.6.2. Depreciation is directly connected with the life of machines and hence it is of utmost importance to determine the lives of equipment used in the calculation of depreciation.

3.6.3. The lives of equipment are mentioned in terms of (i) periods like weeks, months or years and (ii) hours as operating hours, shift hours, plant hours, etc. The depreciation is calculated by dividing the cost of the machine less the cost of tyres less the salvage value, if any, by the life period. Consequently, depreciation is expressed as (i) weekly rates, monthly rates or yearly rates or; (ii) as rate per hour; or (iii) depreciation percentages by quarters of the equipment's expected life. In view of the great importance of determining the method of charging depreciation we elicited information on this subject from various foreign authorities, a summary of which is given below:—

TABLE 3.6.3.

Methods of Charging Depreciation Adopted in Foreign Countries

Sl. No.	Name of Authority	Method of charging depreciation
1	2	3
	U.S.A.	
1	The Associated General Contractors of America Washington.	The A.G.C. and the U.S.B.R. Schedule of ownership expense treat equipment depreciation by *straight line* method by which a uniform percentage of the capital investment is charged off on *monthly basis*. No salvage or scrap value is considered as this is usually negligible in Contractor's equipment. The
2	The U.S. Department of the Interior, Bureau of Reclamation.	

TABLE 3.6.3—Contd.

1	2	3
		monthly charges multiplied by the average number of working months during which the machine is in use gives the annual depreciation. It varies extremely depending on the type of equipment, the climate, nature of work and other factors. The monthly expense rates are based on a single operating shift per day for 30 days a month. When equipment is operated 2 or 3 shifts per day, an additional charge of 50% of the single shift rate for each additional 8 hour shift is made. Daily rate is derived by dividing monthly rate by 30. Largely, equipment depreciation is handled in such a manner that is most advantageous to the owners from a tax standpoint.
3	The U.S. Bureau of Internal Revenue, Income-tax, 'F' Bulletin.	The Schedule reveals the probable useful life *in years*. Annual depreciation rates are considered to be on *straight line* basis.
4	Procedure for equipment transfer evaluation. Tennessee Valley Authority.	The life of 'Rated Equipment' for which records of hours of service and cost of operation will be maintained is given in terms of *operating hours*. Defined as not operating hours, that is gross hours minus all delays. The depreciation shall be computed by the use of *depreciation percentages by quarters* of the equipment's expected life. The depreciations for non-rated equipment is figured on the *monthly depreciation* basis. The transfer values of plant assemblies such as conveyors, mixing plants, etc. which are generally installed for the life of the job, shall be 50% of the cost to the transferring job (excluding installation cost).
	CANADA	
5	The Canadian Construction Association, Canada.	*Straight line method of depreciation.* A uniform *percentage* is charged off *yearly*: the *monthly* percentage rate depending on the average use months per year. Monthly rental percentage is based on a minimum period of not less than one month operational time of not more than 250 Hours month, while the weekly rental is based on operational time of not more than 60 hours in seven consecutive days while the daily rate has a basis of not more than 10 working hours in a 24 hour period. Overtime is charged by the hours at 50% of the straight line rate.

TABLE 3.6.3—Contd.

1	2	3
	UNITED KINGDOM	
6	Federation of Civil Engineering Contractors, London.	The general practice in this country is to calculate Depreciation on an estimated average life in years of the machine. This cost is then usually reduced to an hourly rate by reference to the average annual use, in hours, of the machine.
	AUSTRALIA	
7	Institution of Engineers, Sydney, Australia.	It is the practice here to recover all fixed and maintenance costs by means of a Hire-rate individually calculated for each type of machine and levied broadly on the *basis of the number of days* the plant is committed to a particular project. The hire-rates do not cover operator's wages, fuel costs etc.
8	State Rivers & Water Supply Commission, Melbourne.	The hire-rates are on the basis of time actually in the field less that for major repairs. Plant held idle on the job as standby, is charged 20% of the working rate. The working life is expressed in *hours*.
	FRANCE	
9	Electricite de France, Paris, France.	Depreciation of power stations and electrical equipment is carried out by means of *equal annuities* the value of which is established by dividing the cost by the anticipated *life in years*.
	NEW ZEALAND	
10	Department of Scientific & Industrial Research, Wellington.	*Annual method of depreciation adopted.* The depreciation rate for each item is a *fixed percentage* for each class of plant. The annual depreciation charge is calculated on the cost of the item at full depreciation rate, regardless of time worked, under repair or idle time. The annual depreciation in general, represents 2000 working hours each year, based on a 40 hour week at 50 weeks.
	DENMARK	
11	Christianis & Nielsen Civil Engineers & Contractors, Copenhagen, Denmark.	Depreciate *one per cent* of the original value of the plant per month at site, plus 0.1 per cent of the original value for each working day (8 hours).
	ISRAEL	
12	Ministry of Agriculture, Water Authority, Deptt. of Water Supply, Sewage & Flood Control.	Depreciation based on 2,000 *working hours* per year. The normal depreciation period adopted as per A.G.C. Schedule of U.S.A.,

The above table shows that the Straight Line method of calculating depreciation is the one generally preferred to other methods *viz.* (i) the Production Units method; (ii) the Declining Balance; and (iii) Sinking Fund method because of its simplicity in estimating.

3.6.3. Charging depreciation as a percentage on monthly or yearly basis is adopted by contractors and is most advantageous to them from the income tax standpoint. The method of charging depreciation percentages by quarters of the life of equipment though feasible is cumbersome. Hence we recommend defining lives in terms of hours in case of 'rated equipment' for which records of service hours are maintained. In case of non-rated equipment *i.e.* those pieces of equipment for which on individual records of hours of service or cost of operation are maintained, the depreciation charges should be assigned on monthly basis.

3.7. Definition of Hours

3.7.1. There exists considerable differences of opinion as to how the operating period in hours is to be defined for purposes of calculating depreciation. In this connection we come across the terms (i) the shift hours (ii) clock hours; (iii) operating hours; (iv) plant hours; and (v) the meter hours. These are discussed below :

3.7.2. 'Shift Hour' includes the idle hours occurring in a shift and hence it is not correct to adopt it for working out depreciation. 'Clock Hours' are the working hours as noted by the time-piece and recorded in log books. These are the same as 'working hours' and differ from the 'operating hours' in that they include minor delays in working the machine on a job. 'Plant Hours' and 'Meter Hours' practically mean the same.

3.7.3. The C.P. & M.C. have in their report defined plant hours as under:—

'Plant Hour' means meter hours where meters are working, where such meters do not exist, commensurate effective hours, based on the working of similar other machines with meters should be used; where even this is not possible, the 'effective hour' can be based on the average fuel consumption and work done per hour, which gives the 'load factor'.

3.7.4. In view of the fact, that on many items of plant and equipment 'meters' are not fixed and as the hour meter registrations, is not fool-proof and cannot be relied upon the use of meter hour or plant hour cannot be accepted as a standard method for assessing lives of machines. Also to base life hours on fuel consumption and load factor is not only cumbersome but it lends itself to abuse in recording fuel consumption. Also, fuel consumption is a factor dependent on the mechanical condition of the plant and therefore unsuitable for adoption as a standard.

3.7.5. We, therefore, recommend the use of working hours of clock-hours for determining the life of Rated equipment. Most projects prefer recording clock-hours in log books; and the use of working hours is not only simple but more reliable than any of the other methods. It will not be out of place to mention that almost all advanced countries advocate the

reckoning of depreciation by working hours basis as the soundest and the most practical method.

3.7.6. Our recommendations regarding the lives of rated equipment in working hours and those of the non-rated as monthly percentages are given below in Tables 3.7.6. (i) and 3.7.6. (ii).

TABLE 3.7.6. (*i*)

Life Table of Rated Equipment Recommended by Rates & Costs Committee

Sl. No.	Equipment	Life on Working-hours
1	2	3
1	Air Compressors : Diesel Portable	10,000
2	Batching Plant	50 % of cost to be charged to the project.
3	Core drilling machines	6,000
4	Concrete buckets	10,000
5	Cranes—Crawler :	
	(*a*) Upto 3 Tons	10,000
	(*b*) 3 to 10 Tons	12,000
	(*c*) Over 25 Tons	20,000
6	Cranes—Truck mounted:	
	(*a*) Upto 6 Tons	12,000
	(*b*) Upto 15 Tons	15,000
	(*c*) Above 15 Tons	15,000
7	Crushers:	
	(*a*) Jaw	40% of cost to be charged to the project.
	(*b*) Gyratory	do.
	(*c*) Cone	do.
8	Excavators Crawlers—	
	(*i*) Diesel :	
	(*a*) Upto 3/4 C yd.	10,000
	(*b*) Upto 1·1/2 ,, ...	12,000
	(*c*) Upto 2·1/2 ,, ...	15,000
	(*d*) Above 2·1/2 C yd.	15,000
	(*ii*) Electricity operated Excavators ...	20,000
9	Graders	12,000
10	Loaders	15,000
11	Locomotives : Diesel	12,000

TABLE 3.7.6 (*i*)—*contd.*

1	2	3
12	Mixers concrete :	
	(*a*) Less than 1 C yd.	6,000
	(*b*) More than 1 ,, ...	6,000
13	Rollers—Road :	
	(*a*) Diesel	12,000
	(*b*) Gasoline	12,000
	(*c*) Steam	20,000
14	Scrapers—	
	(*i*) Motorised : (rubber typed)	
	(*a*) Upto 10 C yds	12,000
	(*b*) Above 10 ,, ...	15,000
	(*ii*) Towed :	15,000
15	Tractors—	
	(*i*) Crawlers :	
	(*a*) Upto 89 B.H.P....	10,000
	(*b*) Above 89 ,, ...	12,000
	(*ii*) Wheeled	
	(*a*) Upto 40 B.H.P.	10,000
	(*b*) Above 40 ,, ...	10,000
16	Trucks :	
	(*a*) Diesel	12,000
	(*b*) Gasoline	12,000
17	Trucks—Dumpers :	
	(*a*) Rear dump	12,000
	(*b*) Bottom dump	15,000
18	Well drilling machines 5″—6″	12,000

TABLE 3.7.6. (*ii*)

Life Table of Non-rated Equipment Recommended by R. & C. C.

Sl. No.	Equipment	Depreciation % per month.
1	2	3
1	Air Compressors—Stationary	1
2	Bins	2·½
3	Boats	3
4	Boilers	1·5
5	Cableway	50 of cost to project.
6	Engines—	
	(*i*) Diesel	
	upto 100 HP.	1.5
	100 to 500 ,, ...	1.5
	(*ii*) Gasoline :	
	Upto 10 HP.	2
	11 to 20 ,, ...	2
	20 to 30 ,, ...	2
	Above 30 ,, ...	2
7	Electric Light Plant—	
	(*i*) Diesel :	
	Upto 10 KW	2
	Upto 25 ,, ...	2
	Above 25 KW—100 KW	2
	(*ii*) Gasoline :	
	Upto 10 KW	2
	Upto 25 ,, ...	2
	Above 25 ,, ...	2
8	Hoist—Air :	2
	Chain	2
	Electric	2
	Gasoline : Upto 10 HP.	2.5
	Above 10 ,, ...	2
9	Pile Hammers—Single Acting	1.5
	Double Acting	1.5
10	Pneumatic—Tools :	
	Drifters	3
	Jack Hammer	3
	Pumps	3
	Vibrators	3
	Wagon Drills	3
11	Pumps—Grout :	2
	Pumps etc.	3
	Centrifugal	3
12	Rollers—Sheep-foot	1.5
13	Sand blast outfit	1.5
14	Welding Machine	2

3.8. The Life of Tyres

3.8.1. Though the suppliers always include the price of tyres initially fitted on an equipment in their quotations for the equipment, tyres have to be treated quite separately for the inclusion of *pro rata* cost in the unit rate. On some equipment, the cost of tyres is a substantial part of the total price and their lives are not the same as those of the machines.

3.8.2. The recommendations of the C.P. & M.C. in respect of the average life of tyres of various types of equipment are reproduced below :

TABLE 3.8.2.

Equipment	Life Expectancy Hours	
	Average material	Abrasive material
Scrapers	3,000	2,500
Dumpers—bottom	3,500	3,000
Dumpers—end	3,000	2,500
Tractors	2,500	2,000
Rubber-belt for loaders	3,000	2,500
Drawn scrapers	4,000	3,500

3.9. Depreciation for Idle Period

3.9.1. Equipment depreciates even while idle. We observe that no depreciation is allowed for for the idle period in the working out unit costs on projects. We recommend that a quarter of the full rate of depreciation be charged to the project for idle hours. This will also lead to economy in the capital outlay on equipment on projects.

3.9.2. During monsoons when there is a shut-down on most of the works it can be expected that the equipment would be overhauled for use in the following season. This period which may last for 2 to 3 months, should not be considered as idle time for purpose of charging depreciation for idle hours. Any shut-down during the working season, howsoever long, should be treated as an idle period.

3.10. Two-Shift Working

3.10.1. We recommend two-shift working on large projects and also periods in between these shifts by gangs attending to the machinery. Single shifts working of machines is uneconomical on large projects while *three-shift* working can only be justified where the time for the completion of the project is very limited.

3.11. Method of Determining the Price of Old Equipment

3.11.1. The Co-ordination Board of Ministers have ruled that "the usual formula for determining the price of old equipment would be the book value, less depreciation. In the event of difference of opinon, the matter would be settled by a joint inspection of the two parties, and if necessary, ultimately by arbitration. This procedure, however, should not hold up the transfer of the machines". We agree with these observations and further recommend that before a machine is transferred from one project to another project, it should be completely overhauled and put in a perfect mechanical condition to the satisfaction of an independent authority. We are further of the opinion that each project should towards the end of its completion be required either to scrap the machine or put it in thorough working order at its own cost and get it evaluated by an independent body like C.W. & P.C. The equipment population in the country is so great and stores so large that C.W. & P.C. can afford to have a body of experts on its staff to act as a central agency for the disposal of Stores and Equipment and their transfer from one project to another.

3.12. Repairs and Maintenance

3.12.1. Repairs and maintenance include the cost of labour and spare parts involved in overhauls at the end of the working season, as well as minor replacements or major repairs caused by accidents, etc., which may be required during the working period.

3.12.2. Expenditure on repairs cannot follow any uniform pattern as is the case with operation charges. Nor is there any apparent direct relationship between the depreciation charges and charges for repairs but some assumption about the likely cost of repairs on a machine is necessary and a method has to be devised for debiting it to the unit cost. The only datum available is the purchase price of the machine on which depreciation is based. Practices differ in the correlation of the estimated cost of repairs with the purchase price. Some fix it at some annual percentage of the purchase price and divide this by the number of hours assumed per year to arrive at an hourly cost; others express the total cost of repairs during the life of the machine as a percentage of the purchase price.

3.12.3. We give in Table 3.12.3. our recommendations for repairs and maintenance for the various classes of machines. It must, however, be noted that hourly costs of repairs and major overhauls depend largely

upon the severity of use or working conditions, and the care and attention given to the equipment. The rates given below would apply to average working conditions.

TABLE 3.12.3.

Repairs and Maintenance as Percentage of Depreciation

Class of Machinery	Percentage of Depreciation
1	2
Boilers, conveyors (portable), engine, motors (electric), pumps (high pressure, piston or pump), scrapers, shovels, tractors, bull-dozers, belt loaders, wedlers (acetyelene).	100%
Automobiles, bins (aggregate), bituminous equipment (except kettles), compressors, conveyors (stationary), draglines, graders (motor), hoists (electric and steam), pavers, pile hammers, pit and quarry plans (small), pumps (centrifugal), pumps (concrete), trucks (dump), wagons (dump), welders (gas driven).	80%
Bucket loaders, cable, cement guns, concrete, plants cranes, crushers, drills (pneumatic), hoists (gas), mixer concrete (medium), mixers (motor small), rollers (except sheepsfoot), trailers, trucks (except dump).	60%
Electric hand tools, mixers (concrete, small below 14.8), pipe, pneumatic tools, vibrators (concrete).	40% or less

3.12.4. Contrary to depreciation, expenditure on major repairs should follow an upward trend during the life of a machine, being low in the beginning when the machine is new and higher and higher in later years. It is, however, almost a universal practice to allow for repairs and overhauls in the unit rates on a straight line basis for the sake of simplicity in working. *Unlike depreciation no charge for repairs should be incorporated in unit costs for idle hours.*

3.12.5. The Government of India, in the Ministry of Finance, in their instructions to the Accountant General as contained in their letter No. F-8 (23-EC-II/51) dated 26-9-51 lay down that adjustments for transferring plant use-rate charges to works be made "annually or at more frequent intervals as may be considered expedient". We are of the opinion that such adjustments should be carried out monthly and incorporated in accounts. In the case of cost accounting shorter periods may be adopted, but there is no need to incorporate the figures earlier than one month in financial accounts.

3.13. Repairs and Renewals of Tyres

3.13.1. The repairs and maintenance charges of tyres and tubes are definitely smaller than those of the machines. The following figures of the percentage allowance for repairs of tyres have been adopted in our calculations and are recommended for use.

TABLE 3.13.1.

Allowance for Repairs and Maintenance of Tyres

Job Conditions	Bottom Dump	Rear Dump	Scrapers	Twin-power Scrapers	Loaders
1	2	3	4	5	6
Favourable	40%	50%	45%	50%	40%
Average	50%	60%	55%	65%	45%
Unfavourable	60%	80%	65%	85%	50%
Extremely unfavourable	70%	95%	75%	95%	55%

3.14. The Operating Cost

3.14.1. The Operating Cost includes expense on fuels, lubricants and labour per hour. The fuel and lubricant consumption is dependent on the B.H.P. of the equipment and its type. The labour charges are affected by local conditions, availability of skilled labour, etc. We have recommended in Chapter 2 the scale of wages for personnel required to man the construction equipment. The expenses incurred on the personnel engaged as "leave reserve" and for non-working season should also be included under the cost of labour. We have provided 25% of the total labour charge per hour under this head in our calculations of use-rates of equipment.

3.15. Importance of Preventive Maintenance

3.15.1. While dealing with cost, we should not forget that the worst enemy of equipment is improper maintenance and it is imperative that full advantage be taken of the cost building features, which the modern expensive earthmoving equipment offers.

3.15.2. It is good commonsense to do little things in maintenance which can prevent serious failures later. Not only are the repair charges in a factory to be considered but much more important are the periods of shut-down of works resulting in total loss of production.

3.15.3. Most failures in a well designed and properly built machine are due to wear and tear, shocks, or overloads or a combination of the three. Failures due to wear and tear could be eliminated by proper lubrication, proper adjustment and the replacement of worn parts, before they cause failure of other parts in the assembly.

3.15.4. Failure due to shock could be eliminated by proper driving care and smooth driving operation, good haul roads and making sure that all parts on the vehicle are securely tightened and vibration eliminated. Failure due to overload could be eliminated by prohibiting all overloading.

Regular maintenance of check sheets and control reports along the lines of aircraft maintenance to do "little things" to prevent failures, would go a long way towards effecting saving in cost. Our recommendations on this subject are embodied in Appendix 4.

CHAPTER 4

STORES

4.1. General

4.1.1. A perfect store system should be capable of—

(*i*) Efficiency and economy in management.

(*ii*) Prevention of waste and pilferage.

(*iii*) The exact allocation of all stores bought.

(*iv*) Stock records indicating qualities of goods delivered by outside suppliers not up to the standard mark.

(*v*) Securing protection against running short of materials and stores, the stores ledger showing at a glance the exact stock held from day to day.

(*vi*) Affording protection against over-stocking and thus running the risk of loss by falls in the market value, by deterioration of the goods, and by danger of obsolescence.

(*vii*) Affording check against locking up of capital by carrying unnecessarily large stocks.

(*viii*) Showing up cases of duplicate ordering and afford protection against it.

(*ix*) Continuous test checks with a minimum stock-taking.

4.1.2. Stores Account system should in short be able—

(*i*) to produce figures wanted by the Costing Section promptly,
(*ii*) to present a complete account of receipt and expenditure,
(*iii*) to show bad and good buying,
(*iv*) to indicate quantity and value of stores without stock-taking,
(*v*) to indicate ordering level without inspection, and
(*vi*) to indicate surplus, dead, and unserviceable stores.

4.1.3. The condition of stock accounts on most projects is far from satisfactory as they have failed to fulfil most of the essential requirements. Briefly put, the defects noticed can be grouped as follows :—

(*i*) Purchase registers for Stores Ordered are not maintained to watch supplies and to avoid duplication of order.

(*ii*) Registers for Railway Receipts are not maintained to watch incoming supplies.

(*iii*) Articles are not priced promptly due to the absence of specified procedure for valuation prior to receipts of priced invoices and vouchers for miscellaneous charges.

(*iv*) Payments of bills are unduly delayed on account of non-availability of measurement books containing the bills, due to a lengthy procedure of certification and payment.

(*v*) Issues in the stores registers are wrongly entered due to absence of Code Numbers, resulting in confusion and extreme difficulty in reconciliation of differences.

(*vi*) Half-yearly register of stock is not closed resulting in non-fixation of rates for the ensuing half year.

(*vii*) Physical verification is not generally carried out.

(*viii*) Large accumulation of surplus and dead stores exists at each project, resulting in unnecessary locking-up of capital and unnecessary waste.

4.1.4. The present state of affairs is due to :—

(*i*) Absence of Classification and Condition for stores.

(*ii*) The inadequacy of the existing rules on Management and Accounting.

(*iii*) Lack of Trained Personnel for stores management and accounting.

(*iv*) Cumbersome methods of pricing and verification of stores, closing of Stock Accounts half yearly and enormous increase in the items of stores and their transactions due to the rapid advance towards mechanised methods of construction, now being adopted on works.

(*v*) Unsuitability of some of the existing forms of stores accounting.

(*vi*) Unsuitability and inadequacy of stores houses.

(*vii*) Inadequacy of proper arrangements and methods for storing articles.

4.1.5. Our recommendations on the subject are contained in the succeeding paragraphs.

4.2. Classification and Codification of Stores

4.2.1. According to current practice, stores are classified as under and given no code numbers:—

Small Stores.
Building Materials.
Timber.
Metals.

Fuel.
Painters Stores.
House Fittings.
Miscellaneous Stores.
Manufacture.
Land and Kilns.
Storage.

It is evident that the above classification had been evolved in the past to cover mainly the building materials and cannot serve the requirement of the large River Valley Projects.

4.2.2. There is at present no codification of stores on most of the River Valley Projects. For this purpose the decimal system is more suited than any other. In this system every item is given a code number, which makes for ease and accuracy in posting transactions. It also gives elasticity for expansion according to needs without disturbing the codification of items already in use and is capable of being adopted to the use of machines for stores accounting.

4.2.3. The following main classification and coding of stores is recommended :—

Code Nos.	*Main Classification*
11,000 to 11,999	Building Materials.
12,000 „ 12,999	Plant & Equipment.
13,000 „ 13,999	Auto Stores.
14,000 „ 14,999	Chemicals.
15,000 „ 15,999	Gums, Resins and Varnishes
16,000 „ 16,999	Petroleum, Fuel Oils & Lub.icants.
17,000 „ 17,999	Rubber Goods.
18,000 „ 18,999	Tar & Tar Products.
19,000 „ 19,999	Cement.
20,000 „ 20,999	Steel & Steel Produc ts.
21,000 „ 21,999	Non-ferrous Metals.
22,000 „ 22,999	Electrical Stores.
23,000 „ 23,999	Sanitary Stores.
24,000 „ 24,999	Mechanical Stores.
25,000 „ 25,999	Scientific Stores
26,000 „ 26,999	Hardware Tools.
27,000 „ 27,999	Photographic & Cine Stores.
28,000 „ 28,999	Railway Materials.
29,000 „ 29,999	Explosives.
30,000 „ 30,999	Clothing.
31,000 „ 31,999	Glass & Glass Products.
32,000 „ 32,999	Timber.
33,000 „ 33,999	Fire Arms & Ammunition.
....	....
....	....
and so on to 99,000 to 99,999	Miscellaneous.

4.2.4. Each of the above group can be divided into 99 sub-groups and each sub-group can be sub-divided into 999 items allowing thereby ample scope far expansion.

4.3. Limits of Stock

4.3.1. According to the existing procedure, an upper limit is sanctioned for each division for holding store and the net outlay on stores at the end of the financial year should not exceed this limit. This limit may be revised as and when necessary. For each individual year, a net appropriation is made and it may be plus or minus according as the estimated value of receipts of stores exceeds the value of issues and *vice versa*. But it is always implied that net outlay on stores will not exceed the limit mentioned above. This system may be all right for over-all financial control on stores but for efficient working of stores on large River Valley Projects, every item needs attention and proper planning so that stores may be in a position to supply all the items as required by construction engineers and at the same time there may not be unrequired accumulation of any item. Such accumulation does not only mean lock-up capital but results in continuous cost of storage and safe custody and risk of deterioration, obsolescence and loss.

4.3.2. It is, therefore, necessary that maximum, minimum and normal ordering limits of stock are determined for each article. Such limits will be a great help in efficient and economical working of stores. When the stock of an article is reduced to the minimum limit it should alert the stores keeper to take steps for its procurement and when the stock is at the upper limit purchases are stopped which will save locking up capital. Maximum and minimum limits should be fixed very judiciously with the objective that locked-up capital remains the minimum compatible with regular and timely availability of required stores so that progress of work remains unhampered. It is also considered desirable to fix a limit for normal ordering to be placed for supplies.

4.3.3. Minimum limit on the quantity of an item should be fixed at such a level that the existing stock may generally be sufficient to meet the requirement of works during the period which is necessary for its procurement after the date of purchase requisition. Maximum limit may be fixed by considerations of periodical requirements which will depend on the convenient intervals of replacements and requirements of works.

4.3.4. As a rule the maximum limit should not exceed the requirement of a year plus the minimum limit, unless some such conditions are foreseen that a certain article may become scarce in the near future or its price may go up. The limits for each individual item will depend upon the following factors:—

(*a*) The time required to process an order.

(*b*) The time required to procure the materials after an order is placed within or outside the country.

(*c*) The rate of consumption of the article.

(*d*) Availability of storage space.

(*e*) Economical, commercial units of purchase.

(*f*) The capacity of the store organisation to handle procurement orders, measurements of goods, binning and storing the articles and payment of bills thereof.

(*g*) The provisions necessary to meet the contingencies of accidental needs of certain kinds of items.

(*h*) The minimum amount of money that can reasonably be invested in stock.

4.3.5. If the procedure for procurement orders could be made short and quick, the minimum limits can be reduced thus effecting a saving on the overall investment. From this point of view it is better to have as many items under a Rate Contract as possible so that no time may be lost in inviting tenders etc. This is a pointer to the importance of minimum of centralisation and maximum of the delegation of authority to save time in routines of passing on the papers from one office to another.

4.3.6. The time required to procure materials is dependent upon the availability of the materials in the market and the speed of transportation. When articles are available in the local market, the minimum stock limit should normally not exceed the requirement of 6 to 8 weeks. For materials that have to be imported from abroad, the time required is usually large resulting in the necessity for higher minimum limit. The officer fixing the limits must, therefore, be conversant with the availability of the article.

4.3.7. The rate of consumption of an article will depend upon the time schedule of construction. It is necessary, therefore, that the officer fixing the limit should also have a detailed list of the phased requirements of materials for his works. The availability of storage space scarcely needs any comments except that this may have to be limited to keep down the investment on buildings, and reduce the hazards of fire, theft, etc.

4.3.8. Bulk purchases are always cheaper than piecemeal orders; but care should be taken to see that too much store is not ordered, in an endeavour to purchase at bulk rates, which may not be required in the near future or may deteriorate with time or may otherwise become unuseable.

4.3.9. Theoretically if an order could be placed every day for the requirements of a material in regular demand, the stock limit can be kept very low, say only to meet one day's needs. However, this will throw so much burden on the store organisation, that it will not be able to cope up with the work of ordering, receiving, paying and binning the goods. It is necessary, therefore, to bulk the requirements and indent them at one time. Such bulking of orders should, however, be limited to not more

than 3 months' requirements but deferred deliveries may be asked for when necessary.

4.3.10. Certain types of stores are required to be held against an unforeseen demand, which if not satisfied, might result in dislocation of entire work. The forward indents for contingent stock holding of spare parts is a typical example of this nature.

4.3.11. In the case of mechanical equipment, it is recommended that it should be standardized and the supply of spare parts by the dealer concerned during the life time of the machine should be made a condition of the purchase. Further prices of the parts should be controlled by the Government taking into account net price in manufacturing countries, transport and other incidental charges so that the dealers may not indulge in profiteering. This will greatly reduce the requirement of Government investment in spares which accounts for a great portion of stores on mechanised River Valley Projects.

4.3.12. The reserve limit of stores should be fixed on the basis of a detailed analysis on the above lines.

4.4. Procurement of Stores

4.4.1. Bulk purchasing of stores, in a manner suited to each individual case, can undoubtedly prove an economical proposition.

4.4.2. The various purchasing organisations in vouge on projects in India are the following :—

(*i*) The project authorities themselves.

(*ii*) The State Stores Purchase Departments.

(*iii*) The Central Stores Purchase Department.

(*iv*) The India Supply Missions in other countries.

4.4.3. Stores purchase is a highly technical job involving specialised knowledge of various branches of engineering and it is obvious that no other agency except (*i*) above can possibly afford to have all the experts on its staff without making the organisation unnecessarily expensive and even wasteful. It is also true that the disposal of business in an expeditious manner can alone be assured by agency No. (*i*). No other agency can be more conversant with the exigencies of the situation than the project authorities themselves.

4.4.4. We, therefore, recommend that a Stores Purchase Committee be constituted on each large project and vested with full powers to make purchases direct. In order that these purchases may be made in accordance with the principles accepted by the Ministry of Works, Housing and Supply of the Government of India or by the Stores Purchase Officer, a senior officer of these organisations should be associated with the Committee, as recommended by the Sub-Committee of the Central Board of

Irrigation and Power in their Report on Contract and Force Account System of Construction issued in 1952.

4.4.5. These Committees should ordinarily comprise :—

The Project Manager	*Chairman*
The S.P. Officer, D.G.S.	*Members*
The Chief Mechanical Engineer.	
The Financial Adviser.	
The Chief Accounts Officer.	
The Central Stores Officer	*Member-Secretary*

4.4.6. Budget for the annual stores requirements should be prepared with the same meticulous care as the Financial Budget, supported by Stores Purchases Programme presented before the Purchasing Committee and passed, before any orders are placed, except in emergencies for which special powers should be vested in the Project Manager.

4.4.7. The Chief Stores Officer should be placed directly under the Project Manager, so that the latter may remain in touch with the true position of stores at all times.

4.4.8. Requirements of stores, by consideration of time factor, can fall under three categories :

(*a*) Routine.

(*b*) Urgent.

(*c*) Immediate.

4.4.9. Under the last category, "Immediate", can fall only the emergency requisitions mentioned in para 4.4.6. All normal indents will comprise routine requirements for purpose of procurements. In case of supplementary indents most of the items may be available in stores and some others may be arranged by the routine procedure while some others may still require urgent attention. However, in the interest of the field engineers themselves, the magnitude of urgent and immediate requirements should be kept as low as possible. If their magnitude increases, such requirements cannot possibly obtain proper attention :—

(a) *Routine.*—There should be pre-planning for the procurement of the routine requirements. If recourse has to be taken to direct purchase, procurement procedure should follow the normal channel and lend *itself* to free competition over as large a field in the market as possible.

(b) *Urgent.*—Urgent demands are those against which supplies are required within a month. Procurements will have to be made from the ex-stock offers. The same may be available from some of the firms in Rate Contract with any Central or State agency, or else enquiry will have to be made from a group of selected suppliers whose names are maintained on

the approved list. Short notice quotations or telegraphic enquiries will have to be made to save time.

(c) *Immediate.*—The enquiries for such demands may be made by telephone or telegrams from a few selected suppliers. It becomes sometimes necessary to place orders even without ascertaining the price of an article but this procedure is risky and should be resorted to only with firms of known repute and by officers of adequate status.

4.4.10. In view of the fact that sometimes short-cut procedures have to be resorted to for urgent and immediate demands, it is necessary to clearly define the powers of various officers in this respect depending upon the type of job, its magnitude, and urgency.

4.4.11. There should be a close liaison between the Chief Stores Officer and the Field Engineer. As soon as a schedule of material required is worked out, the field engineer should examine the demand with reference to the materials already available in the Stores with a view to effect necessary amendments. A requisition in form No. N-1 should then be carefully drawn up and sent in duplicate to the Procurement Section.

4.4.12. Purchase Requisitions received in form N-1 from the various Indenting Officers should be consolidated into one or more sets for issue of inquiries by the Procurement Section. As already pointed out purchases through the State and Central Government purchasing agencies have to follow the procedure laid down for them and procurement department should follow the same. For the rest an inquiry should be issued as may be necessary according to the nature of requirement if it is routine, urgent or immediate. Purchase enquiries should be sent out in the form No. N-2. For bulk purchases of routine category exceeding a certain value (to be decided by the State concerned), it is desirable to give an advertisement in newspapers. For purchases of smaller magnitude, the enquiries may be restricted to the list of selected suppliers.

4.4.13. Where detailed speeifications or drawings cannot conveniently be furnished with the enquiry it is often more convenient to ask for samples along with the quotations. The selection of the firm on whom the order is to be placed will, in that case, depend upon the quality of the goods and its relative price which may not necessarily be the lowest.

4.4.14. Inquiries and Tenders

The following are amongst the different methods of obtaining puotations:—

1. Open tenders by advertisement in the press.
2. Limited tenders, *i.e.*, by issuing invitation to a limited number of firms.
3. Single tender, *i.e.*, by invitation to one firm only.

4.4.15. The primary duty of the Procurement Officer is to obtain the best value for the money spent consistent with timely procurement. The adoption of one or the other form of enquiry should be given very careful consideration as this is one of the effective methods of keeping down the rates.

4.4.16. Open Tender System

This system of invitation of tender by public advertisement should be used as a general rule for big purchases, the monetary limit for which should be fixed by the State concerned.

4.4.17. Limited Tenders

Enquiries under this procedure of purchase are issued to a limited number of firms on the approved list of suppliers for the class of required goods. This system is operated upon where the value of the goods required is below a certain limit, to be fixed by the State concerned or when the demand is urgent or immediate.

4.4.18. Single Tender

This system may be adopted when the article required is of a proprietory nature such as spare parts of machines. It should be ascertained if there is any rate contract for the same, so that it may be utilised as far as possible.

4.4.19. Receipt and Opening of Tenders

Quotations should be invited in sealed covers with instruction to the suppliers to indicate on the cover, the nature of enquiry and the due date of opening the quotations. All these tenders should be collected by the Procurement Officer and kept under safe custody until the date and time fixed for their opening.

4.4.20. It is desirable to open tenders and quotations, as far as possible before the tenderers or their representatives, if any, by an officer authorised to do so, who should initial every page of the quotation or tender and conditions and number them serially.

4.4.21. Quotations received after the due date should not normally be admitted. The cases where there is evidence to show that the quotation was actually posted by the party prior to the date of opening but was not received in time owing to the delay in transit may be taken into consideration at the discretion of the officer calling for the quotations, but the tenders of quotations submitted after the scheduled date and hour of opening should be summarily rejected.

4.4.22. A Comparative statement of quotations should then be made and scrutinised by some responsible Official and initialled by him.

Orders of competent authority duly empowered to place the order should then be obtained. In dealing with the competitive quotations the same care should be exercised as is normally taken of the competitive tenders in the Public Works Department.

4.4.23. The Purchase Order

A suitable form of purchase order is given at form No. N-3. The number of copies of the purchase order required will depend upon the complexity of the organisation. In most of the cases six copies, distributed as under, will be found sufficient. These should be filled serially and suitable remarks made as materials are received.

1. To the firm.
2. To the officer receiving store.
3. To the officer holding the store.
4. To the ultimate user.
5. To the Accounts Branch.
6. Office copy of the Procurement Officer.

4.4.24. Any change in the rate or terms, etc. made subsequent to the placing of the orders must be intimated to all persons, to whom a copy of the purchase order was sent.

4.4.25. Repeat Orders

When materials are required during a contract period in excess of the quantities contracted for, and such excess is not sufficiently large to justify the invitation of fresh tenders, there may be no objection to quantities outstanding under the existing contract, if any, being increased suitably by a repeat order, provided that as a result of negotiation more favourable terms are received for the purchase than would have been possible by calling fresh tenders.

4.4.26. The Register of Purchase Orders

A register in form No. N-4 should be maintained by the Procurement Officer and the officer receiving the stores which should be kept posted up-to-date from the copies of purchase orders, etc. and periodically examined to watch prompt supplies, etc.

4.5. Inspection, Receipt, and Payment of Stores

4.5.1. The Railway Receipt received from the suppliers for goods despatched by rail are required to be very carefully handled as they form an important link in the procedure for stores accounting. A record of Railway Receipts should be maintained in form No. N-5 by the official entrusted with the clearance from the Railway.

4.5.2. Returned Stores

Sometimes goods may be returned to stores from works, form No. N-17 should be used for this purpose and drawn up in triplicate. One copy should be retained by the person returning it and 2 copies should be given to the Stores Section to which goods are delivered. The person receiving the Stores should sign both the copies in acknowledgment of the stores and return one copy to the person who sent the stores and keep the other to accompany the "Stores Received Book".

4.5.3. Inspection and Measurements

All consignments of materials received against a purchase order should be opened in the presence of an officer responsible for inspection and count. The inspection should be carried out in reference to the standard specifications or drawings, as indicated in the purchase order. In cases where orders are based on approved samples, the standard sample should be held under a seal by the Inspecting Officer and stores accepted only if they reach the standard of the approved sample.

4.5.4. All materials on receipt should be examined and counted, weighed or measured as necessary. Under the existing Financial Rules measurements have to be recorded in Measurement Books (Form CPWA-23) whether these relate to works or materials. This form of measurement books is not suitable for recording measurements of supplies of materials. Also it gives only a single record of the articles received. The procedure of having to pass books and bills to various tables for payment causes delay in payments and arrears in the completion of the connected records. It is, therefore, proposed to replace this form with a form of "Stores Received Book" (form No. N-8) for recording receipts of stores. This form affords convenience for accelerated movements and timely completion of records. This form should in the first instance be prepared in triplicate by carbon process using indelible ink or copying pencil. One copy is retained by the officer receiving the store, the second is intended for the disbursing officers for making payments and posting ledger and the third for the preparation of an abstract in form No. N-11. The signature and designation of the officer taking measurement should invariably be endorsed thereon. The pages should be machine numbered. Complete instructions regarding its preparation are given in Chapter VI of Part II of this Report.

4.5.5. Rejected Stores

Unaccepted stores should be kept aside and the party concerned immediately notified of the rejection through a Rejection Memo in form No. N-6 with the request for immediate removal of the stores from the Government premises. In order to have a consolidated record of such rejections for future reference, it is recommended that a register in form No. N-7, known as Rejection Register, be maintained. This will also serve as a record of the unreliability of the firms in respect of supply of specific items.

4.5.6. Materials Received Short

The shortages found on opening the consignments should at once be notified to the supplier. In case of damaged packages booked at Railway

Risk, a remark should be given in the Railway Delivery Book, short certificate obtained and claim lodged with the Railway immediately. Record of claims for such shortages should be kept in a manuscript register to watch the clearance. Payment to suppliers for shortages accepted by the Railway as their responsibility can be made debitable to Misc. P.W. Advances, pending clearance on recovery from the Railway.

4.5.7. Payment of Railway Freight

Various methods of payment of railway freights, by cheque, cash and credit notes are at present in vogue in the River Valley Projects. The delay generally attending the adjustment of credit notes, rules out the adoption of this method. Payment by cash would involve handling of large sums of money demanding adequate security arrangements and would not be suitable. On some projects payments by deferred freight system have been allowed by Railways, under which the Station Superintendent sends a consolidated bill once a week for the consignments cleared during the week and then payments made by cheque. This system does not seem to have any special advantage as the bills would require verification, etc. and may result in delays and accumulation. The Committee considers that such payments should be made by cheques and cash to cover the difference between the cheque and actual claims if demurrage, wharfage, etc. which cannot be known in advance, have to be paid. The system was referred to the Railway Board, who have stated in their letter No. 4486-TC dated the 19th May, 1955, that they have no objection to the facility of payment of freight by cheque being granted to such of the Civil Departments of the Central as well as State Government as may ask for it. A copy of correspondence is given in Appendix 6.

4.5.8. Payment of Bills

4.5.8.1. To avoid delays in payment of bills, it is recommended that the suppliers should be asked to send the bills in duplicate giving reference of Purchase Order and Railway Receipt, etc. These should be entered in the bill register form No. N-12 which is maintained to watch their settlement. During the course of our visits it was seen that many of the projects maintain such registers in some form or the other.

4.5.8.2. As the measurement of stores included in the bill should have already been recorded immediately on receipt, the relative "Stores Received Book" should be completed in respect of rates and amount. It will sometime happen that incidental charges like packing, forwarding, insurance, etc. cannot be included in the Stores Received Book until the receipt of bill. In such cases a supplementary Stores Received Book should be prepared including these charges so that the total of the two Stores Received Books will tie up the accounts between the value of the stores received and the expenditure through cash book on the stock sub-head concerned.

4.5.8.3. The receiving officer will connect the bill with the relative Stores Received Book giving its reference thereon. He will check it with entries made therein and the purchase order and record the

certificate of verification required as per instructions for completing Stores Received Books given in Appendix 4.

4.6. Accounting of Receipts and Issues

4.6.1. Direct Purchase Versus Purchases through Stock

C.P.W.A. Code Para 99 (*a*) requires that the cost of stores should be debited to the final head of account concerned or to the particular work for which they are required if either of these can be determined at once otherwise it should be kept in suspense account pending clearance as materials are issued by debit to the specific heads of accounts of work. This system can prove satisfactory only when stores are small and arrangements can be made to keep materials charged to work and those charged to stock separately from each other. It does not suit the large river valley project organisations where all stores are held by a Central Stores Organisation for ultimate users. It is not possible for such organisation to keep the materials charged to works separately from those charged to stock. The Committee invited views of the various project authorities and is of the opinion that in cases where control stores are maintained all materials should be passed through one channel *viz.*, Stock Account. This has the advantages of better control of receipts and issues and knowing the total consumption of an article at a glance from the ledger. It may mean a slight increase in clerical work in stock accounting but the fact remains that it would afford a better control particularly when detailed and clear M.A.S. Accounts could not be maintained for certain types of works *e.g.*, operation and repairs of machines, in accordance with the Code Rules.

4.6.2. At present the Suspense Head "Purchase" is sub-divided into two parts, *viz.*, (1) Purchases for stock and (2) Purchases for works. The Committee has recommended in para 4.6.1. that all purchases of stores should pass through stock account. The procedure for such purchases in para 344 of the CPWA Code is that "when materials are received from a supplier or from other department their value should be credited to purchases on closing the accounts of the month if they have been received for stock and payment has not been made for them during the month so as to secure agreement between the quantity and value account". In this system Purchase Account cannot be prepared until the close of the month specially where stock account is prepared in an office different from the one that is making payment. To avoid this difficulty it is recommended that all purchases even for stock should pass through "Purchase Account" in the first instance and clearance effected as and when bills are paid. This may involve some additional work in the maintenance of "Purchase Register" but this would afford the much needed advantage of having control over the transactions and by this method the Purchase Account and its clearance can be maintained and watched from day to day.

4.6.3. Purchase Register (Suspense)

On almost all the River Valley Projects large balances were found outstanding clearance under Suspense Head "Purchase" mostly due to the

difficulty of identifying items with the bills. To overcome this difficulty it is suggested that references to Store Received Book number and date, Railway Receipt number and date, Purchase Order number and date and the names of some prominent items be given in the column of particulars of item of P.W.A. form No. 67 (Register of Supense) which would facilitate linking of the items and their ultimate final clearance.

4.6.4. Abstract of Receipts

4.6.4.1. At present the abstract of store receipts is prepared for the entire sub-division abstracted monthly in a single Abstract of Stock Receipts which are required to be posted in the Sub-divisional Office from the Register of Stock receipts and issues form No. 8, entries being made in respect of quantity. All transactions of the month need not be entered severally in the abstract but it would be sufficient to show as a single transaction for the total receipt from each source. These transactions are so written as to group the articles by the prescribed heads of stock. After all the transactions of the month have been posted, the total receipt of each article is computed and entered in the column headed "Quantities". No entries are to be made in the Sub-divisional Office, in any of the money columns as these are to be filled up in the Division's Office. The values of the stores received are abstracted in the Divisional Office separately by each of the sub-head of stores and are further classified under 'Cash payment or Purchases'.

4.6.4.2. The existing form No. 9 was suitable for small stores holding a few items only, but they are inadequate for recording large numbers of transactions common to the large River Valley Projects. Moreover the sizes of the columns for transaction are also inadequate to enter the quantities and the value figures. In addition, this form is required to be prepared within a few days intervening the date of closing of the monthly account and the date of its submission. The transactions are so large that it is very difficult to prepare it in duplicate which has to be done by hand, the layout being not convenient for typing.

4.6.4.3. The Committee is of the opinion that when once the receipt of stock has been recorded in the Stores Received Book form, which is already classified by the sub-heads of stock, the duplication of working in preparation of this form is unnecessary. It is adequate to prepare an abstract of the Stores Received Books sub-divided by stock sub-heads to serve the purpose of the existing form No. 9. In view of the fact that we have recommended passing of such transactions through purchases, no further sorting by 'Purchases or Cash Payments' is necessary. The form No. N-11 of Abstract of Receipt recommended by us is given in Appendix 4. This form can be filled up daily from the copy of Stores Received Book which would accompany the abstract.

4.6.4.4. We invited opinion of the various River Valley Projects authorities and Accounts Officers on the suitability of this system. The recommendations of the officers are divided on this subject but the Accountant General, Madras, Andhra and the Tungabhadra Board and

Electricity Department of Madras are already using this system and have stated that they have found it very convenient and simple in operation. We have also recommended the use of ledger system regarding the quantity and value account of receipts and issues. One copy of the Store Received Book will be utilised for posting of the ledger.

4.6.5. Monthly Reconciliation

4.6.5.1. Monthly reconciliation should be effected as under :

1. Total value of the abstract of Receipts should tally with total in the Purchase Register for stock.
2. The total of the stock sub-heads in the abstract should tally with the total of the monthly receipts of the ledgers under each of the stock sub-heads.

4.6.5.2. *Measurements of Gases.* Very often payments are made for leaky gas containers resulting in considerable loss to the projects. The cubical contents of the containers should be marked on them and the pressure measured by a gauge on their receipt. With these two figures and atmospheric temperature, bills for stores could be checked.

4.6.6. Intimation of Receipt of Indentors

The intimation of materials having been received should be at once sent to the indentor by thetores Receiving Officer. He should also watch receipts against the orders placed.

4.7. Pricing of Stores

4.7.1.1. According to para 118 of the CPWA Code an issue rate is assigned to an article of stores as soon as it is brought on stock on the principle that there should ultimately be no profit or loss on stock account, and should consequently provide beyond the original price paid for carriage and other incidental charges, if any, *actually* incurred on the acquisition. This is worked out to the nearest anna and normally remains constant throughout the half year. Appreciable variations are, however, watched and issue rates may and in important cases, shall at once be revised. When closing the half yearly Register of Stock, all issue rates have to be reviewed and revised if necessary to bring them within the market rates.

4.7.1.2. This principle of fixing issue rates has not proved practicable in the case of large stores handled on River Valley Projects due to the tremendous amount of work involved in breaking up the incidental charges for each item and the time required for enquiry about the market rate for each item etc. This work was found in arrears on almost all the River Valley Projects. The following procedure is recommended for adoption in order to meet the requirements.

4.7.1.3. Standard Prices.—The growth in the number and complexity of stores and the need of planning and controlling stores has led to the establishment of standard prices in several commercial organisations. The existing code rule of market price, to be fixed periodically involves so much clerical labour that the work remains almost invariably in arrears and it fails to provide the control data for management. We, therefore, recommend the adoption of the first purchase price as the standard price of the store for the duration of the project, except for violent fluctuations in the prices of important stores when corrigendum can be issued. Any profit or loss on stores due to difference in rates can be charged direct to work periodically so as to make costing of items realistic. Whenever violent fluctuations are noticed, the issue rates of the articles should be worked out as best as possible at actuals plus approximation of items of expenditure not known at the time of receipt and this issue rate will remain constant till such an occasion crops up again.

4.7.2. Delivery of Materials to Central Store

The materials along with the original Stores Received Book are passed on to the Store Holder by the officer receiving the stores. The Store Holder checks up the materials and allots Bin Cards number to each item in the column provided for the purpose in the Stores Received Book and then makes entries in his Bin Card and signs the Stores Received Book. The original copy of the Stores Received Book is then returned to Receiving Officer who should then complete his other two copies in respect of the Bin Card number and pass on the original copy to the ledger section (in division) for further processing. The third copy will be attached to the monthly "Abstract of Stores Received" form No. N-11.

4.7.3. Binning of Materials

4.7.3.1. The materials on receipt in the Central Stores should be recorded on the Bin Cards and the balances in the Bin Card brought up-to-date. The Bin Cards should be kept in the respective bins or in a bound register (like the Kalamazoo visible binder). It may also be convenient at some Stores to adopt card Index Cabinet System located centrally for each Sub-Store. Bin Cards form the most important *initial* record, and hence a great care should be taken to maintain them properly. A record of Bin Cards should be maintained in form N-9 to watch their losses. A new card should be issued only under the signature of the officer holding the stores. There should be a separate Bin Card for each type of item indicating transactions of receipt and issues, with respective Store Received Book or Store Issue Book and the number and the date. Each card should show the location of the articles in the space provided for the purpose *e.g.* File No. Rack No—.There should always be a separate store for all the combustible materials like Calcium Carbide, Cotton waste etc. After the completion of all these entries the articles should be stored in the proper bins allocated to the items. As far as possible, bins should be arranged in the sequence of the store code numbers.

4.7.3.2. The recommended form No. N-10 of Bin Card is given in App. 4. It shows the unit of count or measurement, the opening balances, the proposed maximum & minimum balances and a record of the stock verification whenever contents of the bins are checked by the store Inspector. It is further recommended that the Issue Rate from the ledger should be entered on the Bin Card.

4.7.3.3. The Bin Cards will serve the same purpose as the existing form No. 8 which is intended to be abolished.

4.7.4. Issue of Stores

4.7.4.1. Issues of stores in all cases should be made on the authority of an indent in form No. N-13. The indent should be prepared neatly & clearly in indelible ink or with a copying pencil in triplicate by the carbon-process as all subsequent accounting depends on it. One copy is to be retained by the Indentor and two presented at the stores. One copy is to be retained, by the Storekeeper and the other should accompany the stores.

4.7.4.2. The indents must be signed by the officer authorised to indent on the Store subject to such limitations as the Divisional Officer may impose. The indents should be registered in the Stores Issue Book and after issue of the articles, all the columns in respect of rates, Bin Card No. and materials issued should be filled up in the two copies presented to the store. The indents are then signed by the receiving officer on the Store's copy and by the issuing officer on the second copy in token of having received and issued the required materials. The second copy of the indent together with the materials covered by a Gate Pass if necessary should be handed over to the indentor or his agent who will present this copy at the gate for security arrangements. The security officer at the gate should check the store with the indent and affix his stamp 'Checked' on the indent and sign before allowing the materials to pass out of the Store compound keeping the Gate Pass as a Record.

4.7.4.3. From the copy of the indent retained in the Stores, Issue Book should be prepared. Normally three copies as under Stores Received Book should be adequate but this number may be varied depending upon the size of the store organisation and the accounting set up.

1. For posting ledgers.
2. For preparing abstract of issues.
3. Office copy.

4.7.5. Preparation of Indents for Stores

The following instructions should be observed for the preparation of indents :—

1. Blank space at the end of an indent should be crossed or scored out by drawing double line diagonally across the space.
2. The store keeper should fill in carefully the column meant for materials issued, as in some cases it may be less than the indent quantity or may be nil.

3. Under no circumstances should any correction be made in the indent by the Store-keeper in respect of quantities issued except under the initial of the indentor or his agent.
4. In no case, should addition or alterations be made in an indent as there is no possibility of checking whatever the addition was made before or after the indent was presented. Store-keeper should not accept unattested alterations and additions but should refuse the issue of such indents.
5. Indents should be current only for 30 days from the date of indent where a partial supply is made against an indent, the balance of the quantities should be cancelled and a fresh indent accepted, if and when the supply is again demanded.
6. Indent books should be machine-numbered and kept in safe custody.
7. Separate indents should be required for each sub-head of store and for each work.
8. Normally only about 6 items should be indented on one copy of the indent to leave enough space to fill in other details.

4.7.6. Accounts of Issues

4.7.6.1. According to the existing procedure, (CPWA Code Para III) the issue transactions of the entire sub-divisions should be abstracted monthly in a single 'Abstract of Stock Issues' (Form No. 10) which is posted from the Register of Stock Receipt Issues (Form No. 8) entries being made only in respect of quantities. Several transactions of a month are not shown severally in the Abstract but a single transaction is shown for the total issue to each account or work. The entries are so arranged in the Form 10 as to group them by the Stock sub-head. On receipt of this account in the Divisional Office, value account of issue is prepared on the basis of the issue rates and the storage charges.

4.7.6.2. This procedure was suitable for small stores where the number of items of the transactions were not very large. For River Valley Projects stores, however, this system of preparing a consolidated monthly abstract of issues is found inconvenient, as it is impossible to compile the monthly account in the few days intervening the date of closing and the date of submission of the monthly account.

4.7.6.3. Having introduced the Store Issue Book Form No. N-14 for classified issues, we feel it unnecessary to have to prepare the issue of abstract showing also the items of stores classified.

(*i*) By sub-head.
(*ii*) Work and its sub-head.

We consider that an abstract of the Store Issue Book grouped by sub-heads of stock and each group classified by work and its sub-head would serve the same purpose yet simplifying the day-to-day work without putting extra strain by the end of the account month.

4.7.7. Preparation of Abstract of Issues

4.7.7.1. The detailed procedure for the preparation of the Abstract of Issues will be as under:—

(*i*) Each sectional store holder will prepare separate S.I.Bs. for different sub-heads of stores daily for the issues of the day based on the registered No. of the indents. The total value for a stock sub-head should be carried forward from page to page for an account month.

(*ii*) The sectional store holder should prepare in addition an abstract of the indents issued in a sheet maintained separately for each work and its sub-head and post it under the proper sub-head of stock vide form No. N-15. He should post this form daily from S.I.Bs. and prepare an abstract thereof at the close of the month in a monthly abstract form No. N-16 to which one copy of the S.I.B. concerned will form its accompaniment.

4.7.7.2. At the end of a month, each section store-holder will submit a set of Store Issue Books and a copy of the monthly abstract of issues to the officer who compiles the account of the store. The officer will in turn, consolidate the abstracts of various sectional store-holders in similar monthly abstract form for his entire charge which will give the values of the store issued by store sub-heads, by work and its sub-heads, and by the Fundamental Heads of Account. This will form the basis of intimating the debit to various sub-divisions and divisions work-wise and give the necessary figures for periodical reconciliation of the stock account in as far as the issues by stock sub-heads are concerned.

4.7.7.3. The main advantage of this system is that the classification of the indents by works, their sub-heads and the sub-heads of stock is carried out from day-to-day so that the work remains up-to-date.

4.7.8. Loan of Tools

4.7.8.1. To keep a watch on tools lent out we recommend the use of the Tool Card Form No. N-24.

4.7.8.2. The objects of this Card are :—

(*a*) to provide a plant record of every tool, jig, gauge or other items of movable plant which require control ;

(*b*) to supply a record of plant items issued to operators; with the dates of issue and return.

4.7.8.3. The card is designed for two purposes ; first to list the employees who have used a tool and in particular, to show the person actually in possession of this plant item, and second to list all items handed over to an individual and obtain that person's initials fixing responsibility in case of subsequent claims. The method of working is to make out one card for

each item of plant; and one card for each employee. To distinguish the two types of cards, it is suggested that one of the top corners of the plant card should be cut off.

4.7.8.4. The plant cards are filled according to plant number and the employee's cards according to personnel number.

4.7.8.5. The presentation of the job card is the authority to draw the tools, and the storekeeper notes the employee's number on the plant card and the plant number on the personnel card. He stamps both cards with the date of issue and obtains the initials of the person receiving the tool on the personnel card.

4.7.8.6. Should the tool be required, its location is known and should an employee leave the factory, it is possible to present a list of outstanding tools which should be returned to, before his departure. The transaction upon return completes the cycle, and by showing the stamp date to the employee, the latter is assumed that his liability is cleared.

4.8 RECONCILIATION OF ISSUES, RECEIPTS AND BALANCES

(*ix*) Ledgers may be in bound registers, each page being machine numbered. Alternatively they may be in loose leaves (like Kalamazoo binders) in which case each sheet should bear the signature of the Divisional or Sub-divisional Officer at the time of issue.

4.8.2. Detached Store Sub-division

4.8.2.1. It will sometimes happen that an independent store organisation subordinate to the main store will have to be maintained at the site of work. Sub-store will generally belong to a Sub-divisional Officer.

4.8.2.2. In such cases the Central Store should issue the materials to the sub-divisional store as 'transfer of stock' and the sub-division should maintain its own issues.

4.8.2.3. The sub-store should send monthly abstract of their own ledgers, to the divisional office for monthly reconciliation of the sub-heads concerned undertaken for reconciliation during the month.

4.8.2.4. The sub-divisional store, should be kept supplied with the revised issue rates every time the rates are revised in the divisional office. Normally all such receipts whether in the divisional office or at such sub-divisions should be treated as divisional receipts and then shown issued to the sub-divisions.

4.8.3. Stock Taking

4.8.3.1. The P.W.A. Code lays down that in the case of special stores of construction divisions, where there may be large concentration of stores, their physical verification should be the duty of the executive authorities and should be performed by such agency and in such details as may be decided by the local administration in consultation with the Accountant General.

4.8.3.2. Local authorities have prescribed different regulations in their own P.W.A., Code to deal with the physical verification. Often these lay down that ground balances should be checked at the end of the six-monthly or yearly period. For large stores, such verification cannot be carried out within a few days at the end of a given period. It is necessary to spread the work throughout the year so that each section under various stock sub-heads can be checked at least once a year and preferably twice.

4.8.3.3. In order to achieve an independent check, it is desirable to have an officer of adequate status specially set apart for this work. The status of the officer will depend upon the size and value of the store. On big stores, one or more gazetted officers may be appointed whereas on relatively smaller stores a stock verifier working independently of the officer in charge of the store may be adequate. The Chief Executive of the project would lay down rules specifying the duties of the verification officer which

would mention particular sections of stores to be checked once, twice, thrice in a year, depending upon the importance of the sections, their transactions and the possibility of discrepancies in the ground balance.

4.8.3.4. The verification officer should maintain a register in the following form to control the programme of checking :—

CHECKING

Store	Code No. of Store	Rate of Check				Remarks
		1st cycle	2nd cycle	3rd cycle	4th cycle	

The verification officer should check whether any of the store checked by him has become unserviceable. If so he should submit a report showing the articles, quantity and the condition of such store, indicating the action necessary for its better preservation. Such unserviceable store should then be dealt with, in accordance with the Code rules.

4.8.3.5. Instructions.—The following instructions should receive special attention :—

1. The subordinate incharge of the store should render full assistance to the stock verifier in his work.
2. The Bin Cards should be brought uptodate by the stores organisation before a section is put to verification, and the balances shown therein got certified as correct by Accounts Branch.
3. The stock verifier should prepare a list of the articles in the section to be verified from the Bin Cards and record, the Bin card balances, the ground balance and the difference in a form No. N-19.
4. Articles of allied nature should be verified at the same time to see whether there is any inter-mixing of these.
5. The check should be carried out in the presence of a representative of the stock-holder so that the necessary assistance can be rendered to the verifier in identification and count of the articles and discrepancies minimised.
6. Where weighment of large quantities is necessary, the number or weight may as alternatively be determined by weighment and count on the basis of an average sample weight or count of quantities selected at random for articles, coke, etc., the materials may be verified on the basis of stock measurements and standard weight per unit of volume. Small discrepancies likely to arise in sure methods of check may be ignored,

4.8.3.6. Four copies of the verification report should be prepared which should be utilised as under :—

(*i*) to the Chief Executive of the Project;
(*ii*) to the Officer holding the stock;
(*iii*) to the section stock-holder; and
(*iv*) verifier's own copy.

4.8.3.7. The Verification Officer should initial and date the Bin Cards of articles checked by him. The officer incharge of the store should scrutinise the discrepancies. If there are any arithmetical errors these may be set aright under the initials of the verifier; the shortages and excesses should be dealt with in accordance with the para 134 of C.P.W.A. Code. The discrepancy report should be finalised and action taken within one month of checking.

4.8.4. Treatment of Stores Deficiencies

4.8.4.1. Deficiencies should be carefully inquired into with a view to discovering the cause. This may consist of one or more faults, such as :—

1. Issue of materials without requisition.
2. Issue of more materials than requisitioned, either by failure to alter a requisition note to agree with issues, or by guessing quantities.
3. Misappropriations of goods from store.
4. Wastage of stores through careless handling, faulty protection, or natural causes.
5. Failure to make the necessary charge for goods sold, no requisition note having been issued.
6. By merely giving 'Good' measure or weight. It is simply the 'Scales Pull'.

4.8.4.2. Whatever the reason for the shortage, certain actions are necessary.

1. The deficiencies must be written off the Stores Accounts, and the Stores Control Account.
2. The authority for writing off, and clearing up, must emanate from a person of responsibility, preferably the head of the department.
3. They must be charged up to something, or to somebody, and what, or who this is, and can be determined only in the light of the fullest knowledge available.

4.8.4.3. Assuming the losses are *bonafide*, and as an indication of how they may be treated, it is suggested that efforts be made to find out what jobs have been undercharged (in quantities) with stores issued,

so that errors may be rectified. The Cost Accounts Section should be of great help in this connection.

4.8.5. Writing out Surpluses and Deficiencies in Stores Accounts

4.8.5.1. It has already been recommended that surpluses and deficiencies be written out of the books without delay. The reasons for prompt action are :—

1. The Stores Accounts become inaccurate and exhibit a false view of the actual positions.
2. The Cost Accounts are also wrong and should be corrected.
3. If the seriousness of inaccuracies is not impressed on all who have been responsible for them, the full benefit of a system of stores accounting is not obtained, and there is no incentive on the part of the delinquents to be more efficient.
4. An unscrupulous storekeeper can, if he so wishes, rectify surpluses whether by pilfering, or by deliberate issue of materials without, or in excess of, proper requisitions.
5. The storekeeper can also try to put the deficient balances right by giving short weight of measurement or by other means more or less suitable, according to his ingenuity.
6. Surpluses and deficiencies may balance one another as a whole or in part, and in consequence large disparities of both descriptions may be wholly or partly obscured.

4.8.5.2. The treatment of surpluses should be based on the results of an inquiry of the same description as that suggested in the case of deficiencies. Accounts that have been overcharged in issues should also be put right.

4.9. OTHER STORES

4.9.1. Apart from stores held in stock under central stores, the following types of stores also have to be handled and their accounting done :—

(*i*) Charged Stores.

(*ii*) Returned Stores.

(*iii*) Scrap, Empties and Surplus Stores;

(*iv*) Tools and Plants.

4.9.2. Charged Stores

With the Committee's recommendations for passing all stores through 'Stock' and discontinuance of M.A.S. Accounts on River Valley Projects, the above type of stores must disappear. If however, such stores do appear these should be kept apart from the regular stores prominently marked as 'Charged Stores'. The transactions of issue of such stores

should also be passed through Stores Issue Book which should be marked prominently as 'Charged Stores'.

4.9.3. Returned Stores

4.9.3.1. There will be two types of materials returned to the store.

(*a*) New Stores remaining unutilised on completion of works.

(*b*) Old Stores salvaged from works.

4.9.3.2. Such articles should be returned to the stores so that their future utilisation could be planned. These should be presented to the store accompanied by return store note in form No. N-17. The Central Store will then deal with the articles so received in the same manner as the account in the S.R.B. form.

4.9.4. Scrap, Empties and Surplus Stores

These should be given the same treatment as outlined for 'Returned Stores'.

4.9.5. Tools and Plant

In case of Central Store organisation being established on projects, the articles of Tools and Plant should also be handled by it and account kept according to the existing rules.

4.10. Store Management

4.10.1. Location

Store should be located at sites where from the minimum of carriage of materials to the various departments served is involved. They should preferably be close to the Railway Station. Very often store buildings not originally intended to serve for stores are used for storing the goods received in the earlier phase of a project. Many such buildings are a make-shift, but the exercise of ingenuity can lessen the disadvantages of this nature. It is desirable to plan out storage building carefully and rather on the liberal side to avoid damages and deterioration of the stores. We noticed that almost all the projects stores did not plan and construct their buildings adequately in advance and in almost all the cases the estimate of the space required enhancement.

4.10.2. Space

4.10.2.1. One ever-recurring and chronic difficulty is the lack of space. This may be alleviated by the use of gangways not wider than is necessary to handle, in and out, the large and awkward parts. In ordinary circumstances 2 feet and 2′-6″ gangways will be sufficient.

4.10.2.2. The heavier goods should be stored in the lower bins which should be kept bigger. If the bins run higher than 6 ft. the lower bins should be strong enough to permit a man to climb the first three or four bins. Where necessary, portable ladders should be provided to approach the upper portion of racks so that the space can be utilised. Racks of 10′ height should be suitable. There should be at least 4′ clearance from roof to the top of bins to prevent damage due to sweating. The provision of extra space on the top also lessens the heat effects on men working at the top of the bins.

Ideally, only one type of item should be stored in each store bin but frequently many types of items have to occupy a bin due to lack of space. In such cases the bin should be partitioned so that different types of items are segregated. Where it is impracticable to partition the bins, the items selected to occupy the same bins should differ from one another as much as possible. Orderly piling of the items one upon another in tiers within the bin makes best use of the space in the bin and also helps in quick counting whenever required.

4.10.3. Type of Bins and Racks

Steel racks with bigger bins at the bottom and smaller at the top are recommended for the storage of spares, electrical materials, small tools and general stores of lighter types. Ready made steel racks to standard dimensions are available in the market. At some places masonry racks can be used with advantage for the storage of heavy goods like ferrous and non-ferrous metals, paints etc.

4.10.4. Lighting

Storage racks are generally built up high, because of the limitation of space. Natural lighting is, therefore, generally poor. The correct and prompt service requires good lighting of stores, and this can be assisted by painting in light colour the walls and ceiling such as the aluminium paints. The provisions of portable inspection lamps, which will shine right into any bin should invariably be made even with an adequate over-head lighting system.

4.10.5. Cleanliness

Dust collects quickly in stores, particularly where the floor is of concrete. Washing the floor is ineffective and the concrete should be treated with some sodium silicate product in order to keep down dust. A vacuum cleaner is desirable for this purpose.

4.10.6. Protection of Stores

All the stores after inspection should be wrapped in original wrappers after greasing. If these are torn out in the process of checking them, new wrappers should be provided. Special care should be taken in storing all the small spare parts so that they are absolutely

protected against (rust) etc. It is desirable to wrap assemblies in transparent coverings, and or paint the articles with anti-rust paint in order to save the trouble of greasing and degreasing. The store should be made absolutely leak and damp proof. It should be the duty of the officer in charge of store to see that proper rust proof paints and disinfectants are used freely to see that no damage is being done to any item of stores under his charge. The gaskets are very delicate parts to handle and are liable to be damaged by dampness works, etc. It is recommended that separate drawers in cabinets should be used to arrange the gasket of various sizes. The smaller one can easily be arranged in the space within the larger ones. Tyres, tubes and rubber goods should be placed in a dark and cool room to guard them against deterioration by heat and light to which rubber goods are so very sensitive.

4.10.7. Lettering

It is desirable that a uniform and well considered system should be used for numbering bins, compartments and stocks. The letters and numbers should be at least 3″ high, and placed at eye level if possible. Numbers should be assigned in a uniform manner, and they should run from left to right uniformly throughout the store, and from bottom to top of the store so that the bin number also indicates in a general way its location. Colours may be used for indentification of materials if desired.

4.10.8. Fire Protection

4.10.8.1. Special attention should be paid to the fire hazard. No oils, varnishes, inflammable compounds, celluloid, kerosene, petrol, packing materials etc., shoud be stored with other materials. Materials of this nature should be stored separately, at a safe distance from other stores so that the risk of spreading fire is minimised. Fire extinguishers and fire buckets should be placed at different places in all the stores in sufficient numbers for emergencies. Fire fighting drills be held to fight fire in emergencies. Fire fighting squads should be formed from amongst the staff who may be given a small allowance to keep them alive to the sense of their duty. The stock compound should be served with a net work of pipe line and fire-hydrants, supplied from water storage under adequate pressure to bring fire hoses into operation whenever needed. It would be desirable to consult fire-fighting experts and follow their advice about the layout and arrangement or fire fighting.

4.10.8.2. Notice boards both in English and the regional language should be placed at the entrance of store houses and on other places where materials are placed, prohibiting smoking, of lighting fire in the store houses etc.

4.10.9. Security Measures

4.10.9.1. The methods and forms recommended in all phases of accounting for controlling these essential commodities have been designed

to eliminate or minimize losses from pilferage. Notable instances that have a very potent effect in this matter are :—

1. Checking invoices with the Stores ledger;
2. Checking invoices with the Stores Received Books;
3. Checking invoices with order on suppliers.

   (Items 1–3:) Ensuring that all goods paid for are taken on to store charge and fully accounted for

4. Detailed stocks and stores account;
5. Making frequent spot test checks on stores, etc., by internal audit or other staff with the Stores Ledger Accounts and Bin Cards;
6. Taking a complete periodical stock and comparing the finding with Stores Ledger Accounts;
7. Instituting periodical returns from departments, branches, and stores to head office;
8. Comparing and linking up stores received with the financial books;
9. Internal automatic check by spreading the work over as many persons as practicable;
10. Effecting checks on issues by reference to S.I.B's. and the user;
11. Branding by distinctive mark, plant, etc., for retention on the premises; and
12. In respect of issue to jobs a good check on consumption is effected by 'Measuring up' the work done. A competent person can compute with considerable accuracy the quantity of materials required in a given product, taking into account unavoidable wastage. The figures comprised in detail as to materials used (as shown by cost accounts) help to locate pilfering and unnecessary wastage by the workers on the job in question.

4.10.9.2. In certain cases, it may be thought appropriate to institute direct physical precautions against theft of materials by methods such as :—

(a) the use of clothing of overall without pockets by those who handle stores of small dimensions but of appreciable value.
(b) the examination of persons leaving the premises by inspectors or other persons, and
(c) the checking of goods taken out of or off the premises, by doorman, yardman, etc., by a comparison of the declared contents of packets and the label thereon (filled in by one person and duly verified by another, adding his signature) with delivery and issue notes, invoices, or pass out orders held by the person removing the goods.

4.10.9.3. The foregoing remedies for avoiding or minimising pilfering are not equally applicable to all circumstances. The most appropriate method to adopt, would depend on factors such as :—

1. The nature of the stores, some are small and valuable, others less easy to steal and difficult to remove unnoticed;
2. The location of the stores building or compartments; and
3. The presence of other employees therein. (It is more difficult to pilfer articles if somebody else knows it). Each case should be considered on its merits.

4.10.9.4. The Security staff should be provided for all stores in adequate numbers and where necessary Police Guards should be provided. The store yard should also be well lighted at night.

4.11. Lack of Trained Personnel

4.11.1. Raw officers and subordinates are often placed in charge of large stores without knowing the A. B. C., of store management, or having familiarity even with the names of the stores. This lack of knowledge and experience coupled with the absence of Code numbers results in wrong physical issues of stores and in wrong accounting subsequently, creating confusion all over.

4.12. Insufficiency of Staff

4.12.1. Some of the difficulties in this connection will disappear as soon as the store personnel are given proper training and proper rules and procedure for stores accounting and management are introduced. On projects having big stores involving thousands of daily transactions, accounting machines can be used with advantage resulting in speeding up of work and greater degree of accuracy. They are, however, difficult to maintain, are expensive in the initial cost and their hiring charges are high. Their use, can, therefore, be recommended at present only to the projects which are largely mechanised and have costing cells.

CHAPTER 5

COST CONTROL

5.1. Contents of a Project Report

5.1.1. A project report should be able to present to the reader a complete picture of the socio-economic effects of the undertaking and comprises items like the topography, geology, hydrology, climate, communication, soil characteristics, ground water conditions, engineering plans, estimates of quantities and cost, analyses of rates, programme of work, schedule of the annual requirements of equipment, men, material and stores and funds, specifications of work and financial forecast. It should also be accompanied by the following documents :—

1. A schedule of basic wages.
2. A schedule of basic rates of materials.
3. A schedule of transport rates.
4. The equipment prices and their use rates.
5. The basic outputs of men and machines.
6. The standard methods and units of measurement.
7. The classification of accounts.
8. Estimates.
9. Codes for stores and accounts.

The first five of the above items have been dealt with elsewhere in this report. We will deal with the rest in this chapter.

5.2. Standard Methods and Units of Measurements

5.2.1. The units to be adopted for bidding purposes and for measurement and payments of work should conform closely to the Standard Estimating Practice. Typical units are given in Annexure 1.

5.2.2. The Institute of Engineers (India) has brought out a publication entitled 'The Standard Method of Measurements of Building & Constructional Works', which deals mainly with items relating to the Building Industry. We recommend that a comprehensive Mannual on similar lines be got out for the River Valley Projects.

5.3. Classification of Accounts

5.3.1. A standard classification of the items of work is essential for the correct compilation of accounts and reconciliation of figures between costing and accounts sections.

5.3.2. The present system of classification fails to meet the present day requirements of the large River Valley Projects, which contain numerous and varied features that they cannot all be denoted by the 26 letters of the English alphabet and this handling very often leads to confusion and be responsible for the inability of the project officers to furnish cost figures for the various items of work in spite of their best efforts.

5.3.3. A simple system of classification of estimates and accounts is given in Appendix II.

5.4. Codification of Items of Work and Stores

5.4.1. Accounts and stores are not codified at present. They have to be described and result not only in waste of time in writing but may often also result in serious accounting mistakes, which become difficult to locate. It is, therefore, essential that a proper code be laid out for all items of stores and accounts and the same code be followed in the preparation of estimates. (App. II & Chapter 4 para 4.2.3. gives the code).

5.5. The Estimate

5.5.1. Estimate being the foundation for cost control should be prepared with meticulous care by a competent Engineer, thoroughly familiar with construction methods and costs. It should be prepared in such detail and in such a manner that may enable the cost engineer to split up the cost into the elements of work with a view to make comparison of actuals with the estimated figures possible. If this is not done, cost reports will not be readily assimilated and make comparison at a later stage difficult if not impossible, thereby rendering the cost section inoperative and ineffective.

5.5.2. The estimate indicates the probable cost and not the actual. The agreement of the former with the latter will depend upon the estimater's skill the correct visualization of the work as also the accuracy of estimating methods employed by him. The preparation of an estimate of a real value is a skilled work and calls for the highest training, wide experience and sound judgment.

5.6. Physical Quantities

5.6.1. A River Valley Project involves expenditure in two forms *viz.*, structural and physical. The estimate takes off quantities in units of work from the drawings in terms of brick-work, concrete, stone masonry etc. These quantities "called structural quantities" are priced at a composite rates called "unit rates" or "item rates" for purpose of estimating. These quantities should also be converted into physical quantities such as materials, labour, plant use expendable stores etc., which can be precisely priced at prevalent wages and basic market rates of materials. Appendix IV contains a form N-33 recommended for estimating purposes.

5.6.2. The following items have a great bearing on the actual cost of a project—

1. The Contract.
2. The Documentation.
3. The Contractor.
4. Planning the job.
5. The organisation
6. Cost Control;

and are dealt with in the succeeding paragraphs.

5.7. The Contract

5.7.1. Contract may be classified as follows:—

1. The lump-sum which provides for the payments to the contractor on the basis of a total amount to cover all work and services required by the plans and specifications. Its use is indicated where the types of construction are largely standardised and where a variety of operations is required. Plans & specifications should be comprehensive and should show in complete detail the requirements of the work. Work orders showing deviation after the contract is signed, prove expensive and even lead to controversies and disputes. Furthermore, when the plans are indefinite the contractor tries to inflate his bids to cover the worst case. If these hazards are avoided, the Government has the advantage of knowing in advance the exact cost of the work, and the measurement of work and payment thereof are considerably simplified.

2. The Unit-Price contract which includes a breakdown of estimate into number of units of each type of construction and a price for each unit. When the work requires large quantities of a relatively few types of construction, and the volume of work cannot be exactly determined in advance, the unit price contract has many advantages. It is elastic as reasonable variations may be made in amount of work to be done without formal deviation from orders as long as the changes are restricted to the tendered items. The plants and specifications must show the nature and details of the work, but its limits may be left more or less indefinite, the magnitude and scope of the work being indicated by the estimate. Under these conditions the contractor is not forced to gamble on uncertain conditions.

3. Cost-plus-a-Percentage of cost contract provides for the contractor's profit on the basis of a fixed percentage of the actual cost of the work. In common with all negotiated contracts this type permits the beginning of construction before the plans are completely developed, resulting in an

important saving of time in the completion of urgent projects and the government may make any desired changes in the plans and specifications as the work progresses. It has the disadvantage to the government that the contractor's compensation is increased by an increase in construction on cost. Therefore, there is no incentive for the contractor to economise during construction.

4. Cost-plus-a-Fixed fee to eliminate the above defect, the contract may be cost-plus-a-fixed fee type which provides for payment to the contractor the cost of the work plus a fixed amount as fee which is determined from a consideration of the character of the work and its estimated cost. Thereafter the fee remains fixed although the actual cost of the work may vary from the estimate.

5. As an added incentive to the contractor to keep the cost of the work at a minimum, a profit-sharing clause is sometimes added to the cost-plus-a-fixed fee contract. The profit-sharing provision allows the contractor to receive a share of any saving if the actual cost should be less than the original estimate.

5.7.2. The principal argument against cost-plus-a-percentage types of contracts is that the owner has no way of knowing in advance what the work will cost. This objection may be overcome to a considerable degree by placing a maximum limit on the cost of the work. That is to say the contractor is reimbursed for the actual cost of the work plus his fee, provided that the total amount does not exceed the maximum limit provided in the contract. If the total amount should exceed the maximum limit the contractor is held responsible for the excess and receives no compensation over the guaranteed ceiling price. This type of contract removes some of the uncertainties from the ordinary cost-plus-percentage contract but requires that the plans and specifications for the work be sufficiently developed to permit the establishment of a reasonable ceiling price.

5.7.3. A contractor may deliberately inflate the construction cost in order to obtain a corresponding increase in his fee. This may be done by padding payrolls, taking commissions on materials purchases, and the like. For these reasons we do not recommend the cost-plus-a-percentage forms of contracts for general use. Extra work and change orders may, however, sometimes be handled conveniently under this system.

5.8. Selection of the Type of Contract

5.8.1. It is advantageous to adopt a competitive bid contract when sufficient time is available to work out the plans and specifications in detail. Generally, however, the unit price form is used for all Civil Engineering contracts and is recommended for general adoption.

5.8.2. A negotiated contract will be indicated when it is desirable to begin work before the completion of detail plans and specifications thus assuring earlier completion of the work when the requirements of the project cannot be determined definitely in advance of the early phases of construction; or when the nature of the project is such that an accurate estimate cannot be made for bidding purposes.

5.8.3. It sometimes happens that the Government contemplating a construction project desires to deal with only one party for all services, both engineering design and construction, in connection with the work, this is a so called "turn-key" or "package" job. This type of contract may be drawn either on a firm price or on one of the cost-plus forms and the planning, design, plans, specifications, and construction services, are included under one contract. Combined engineering and construction contracts of this nature are not, in public interest.

5.9. The Documentation

5.9.1. The specifications are an integral part of a project whether the work is to be executed through a contractor or by the departmental agency. Their composition, therefore, must be logical and systematic, otherwise they will result in repetition, omissions and conflicting statements which lead to confusion and disputes with contractor during and after the construction and can thus considerably add to anticipated costs.

5.9.2. Looking to the number of controversies arising in the interpretation of contracts and specifications, we consider it necessary that greater attention be paid to contract documents to avoid all ambiguities. It would be recognised that the preparation of documents for River Valley Projects is best done by qualified quantity surveyors experienced in taking off and pricing.

5.9.3. We like to bring out one important aspect of contract documents. It often happens that junior officers knowingly or unknowingly make commitments to contractors which have a far-reaching effect on the contract while they have not the requisite authority to do so. On the other hand, the contractor seldom, if ever, places himself in the wrong, fortified as he usually is with advice from astute lawyers. It is, therefore, very necessary that agreements should contain a clause invalidating all commitments from any but the legally authorised sources. Also, on large projects legal advice should freely be available to the Contract as well as the Claims sections of the Project.

5.10. The Contractor

5.10.1. One of the most important items for the successful execution of a work is the selection of the right type of contractor.

Selection of Contractor—The selection of the contractor should be based primarily on the following considerations ;—

(a) Previous experience in the particular type of work.

(b) Reputation for fairness and excellence in performance.

(c) Quality and experience of personnel.

(d) Available working capital.

(e) Available plant and equipment.

(f) Normal volume of work per hour.

(g) Incompleted works in progress.

(h) Available work capacity (difference between normal volume and incompleted work in progress).

Information along these lines should be collected and classified systematically preferably by some sort of questionnaire. Analyses of this data will usually indicate one or more contractor suitable for the work. A pre-selection of bidders is, therefore, recommended

5.10.2. The necessity to advertise for bidders, to accept bids from all who are inclined to compete, and to award contracts to the lowest possible bidders, introduces problem in the awarding of contracts for public works which are not encountered in private construction, where the list of bidders may be selected without restriction. For a bidder to establish responsibility under these conditions, usually means the furnishing of required security and a record free from defaults or proved dishonesty. Thus incompetent and over extended contractors and those with inadequate financial resources may be placed, more or less, on an equal footings with responsible bidders in the competition for the awarding of the contract.

5.10.3. The employment of unqualified contractor usually leads to difficulties during the operation of the contract. Also slow progress, unsatisfactory quality of work and excess cost may result. Moreover, incompetency is one of the very important factors in contractor's defaults which always cause inconvenience, delays, and extra cost to the owner. To avoid or reduce these difficulties, the pre-qualifications of bidders is recommended. The object is to determine before the contractor is allowed to bid, whether he is responsible and competent to satisfactorily complete a given construction contract.

5.10.4. The pre-qualification procedure requires the contractor to submit a formal application to bid. The application contains sufficient information on the lines outlined in para 5.10.1. The consideration of these factors will usually eliminate unfit contractors from the list of those permitted.

5.10.5. The chief advantages of pre-qualification are that lists of competent bidders will be established in advance when there is sufficient time to investigate contractors qualifications. When all the bidders are qualified, the contract is simply awarded to the lowest bidder and the public official, who awards the contract, is saved the embarrassment of rejecting a low bid from an unqualified bidder. Contractors are saved the time and expense of preparing bid for him for work in which they are unqualified, by inexperience and lack of financial or other resources. Failures and defaults of contractors during construction are minimised by the elimination of unfit contractors, which results in the saving of time and cost in construction work.

5.11. Organisation

5.11.1. After the estimate has been sanctioned and the agency for the execution of the work decided, a suitable project organisation has to be set up. A sound organisation should satisfy the following requirements :—

(1) Separation of functions, such as accommodation procurement, engineering, laboratory control, etc.

(2) Setting the line of functions with their logical sub-divisions so that there is no over-lapping or conflict and so that no individual receives orders from more than one individual—his immediate superior. He may, however, receive aid and advice from Staff Officers or Assistants.

(3) Clear cut distinction between line and staff functions and functional control.

(4) Clear cut specifications of each job.

(5) Suitable and adequate delegation of authority and responsibility for each member.

(6) Selection for each position and most suitable person without fear, favour or political influence.

5.12. Objective of the Organisation

5.12.1. The objective of organisation is the actual superintendence of operations, and its prime purpose is to obtain the maximum production at the minimum expenditure. To achieve this end, it should know :—

1. How the actual production can be made approach the estimate.

2. The production that is acutally being obtained.

3. The best production that can be obtained.

5.12.2. To make the actual production approach the best estimated demands competent planning, keeping men and machines in good working conditions, and above all, furnishing sufficient incentive to the workers to ensure their best performance. To determine the best production that can be obtained, time and motion studies are employed.

5.12.3. A typical organization chart for a large River Valley Project is given in Annexsure 2.

5.13. Planning the Job

5.13.1. The construction of River Valley Projects is essentially a manufacturing process and as such it is affected like any other industry by all the problems of economics, management, labour and production. It, however, differs from the latter in one important respect *e.g.*, that while in the production of the most of the industrial commodities, manufacturing methods are more or less standardised to facilitate mass production in a centrally located manufacturing plant, and the finished product is transported to its place of use, in the construction industry the product is necessary for each construction job, also each project is peculiar in characteristics. It is particularly so with storage schemes, where the principal features of one project are vastly different from those of another.

5.14. Flow Diagrams

5.14.1. Flow diagrams are used more and more in the construction industry to show the position and capacity of each stationary machine or operation, including the method of transportation from one to another. The diagrams are of great use in planning the work. They are not to be drawn to scale and may be shown in plan or section. Simple diagram for cement mixing plant is shown in Annexure 19.

5.15. Planning Charts

5.15.1. Charts (Annexures 3—9) show diagrammatically the various steps used in planning expenditure on labour, equipment, materials and miscellaneous items of a project.

5.16. Planning, Plant and Equipment

5.16.1. The planning of a suitable equipment is an intricate job as it does often require a composite group of machines to work in harmony with each other so as to achieve the maximum efficiency in output and cost. Several combinations have to be investigated so as to arrive at the best, keeping an eye also on their availability in time. Equipment time schedules are worked out to show the various pieces of major equipment and the duration for which they are required. An illustrative chart showing the equipment schedule for a concrete dam is shown in Annexure 10.

5.17. Planning of Labour

5.17.1. It is necessary to determine sequence of operations and trades so as to plan a proper labour requirements of a job. An illustrative chart, Annexure 15, shows a typical foree report.

5.18. Control of Expenditure

5.18.1. Exercise of control over expenditure is an integral part of good management. The cost is not an end in itself but the object should be to provide ways and means and whereby cost can be controlled and cut down. Cost control should increase efficiency by indicating waste, leakage of materials, waste of time and uneconomic overheads.

5.18.2. Most of the large River Valley Projects are being executed under a field organisation which works on a functional basis. Under such a set-up no divisional officer would know or can be held responsible for the overall cost of a project or that of any unit thereof. The work being divided on a functional basis, it has to be priced for each function and then collected to know the overall cost and the unit rates. Indirect or distributive costs constitute a large fraction of the total cost of a work, especially where a large amount of plant serving many parts of the project simultaneously has made the cost distribution mandatory. Therefore, the need for a *Cost Section* is now keenly felt on all large projects. There is a general concensus of opinion both among Engineers and Accounts Officer consulted by the Committee that there should be a *Cost Section* besides the present accounts organisation for each sizable project.

5.19. Cost Section and its Functions

5.19.1. The Cost Section is to function as an independent fact-collecting agency and compiling data for presentation to executives in a form most serviceable to them. Its major objectives are, (*i*) to furnish the maximum amount of information from both operation and cost angles, (*ii*) to present in the most practical way the facts that reveal actual performances and to aid in the attainment of high standards of efficiency, and, therefore, of realisation of maximum economy, and (*iii*) to aid in determining operational policies. In short, cost accounting would aim at accounts for operators and project managers instead of accounts for accountants. It is thus more an adjunct to Engineering Departments particularly of estimating and planning them to the general accounting department.

5.20. Costing System to be Flexible

5.20.1. The Costing system should be flexible so that it can be readily adapted to changing conditions. It should be simple and practical to operate so that it may be conveniently kept up-to-date in the peculiar difficulties of construction jobs. We, therefore, consider that a complete review of the system and the forms in use should be carried out from time to time in order to eliminate any unnecessary features and to adapt the system to suit the conditions under which a project is executed.

5.20.2. The system will serve no useful purpose unless the data compiled is used by the technical personnel to study and assess the progress made on each job, and to compare the efficiency of labour and machine with the best attained under similar conditions.

5.21. Conditions essential for an efficient costing system

5.21.1. The conditions essential for an efficient costing system are :—

(*i*) that arrangements and designing of the cost accounting system should be suited to the organisational set-up and the methods of construction on a particular project, at all levels of management down to the smallest field of activity ;

(*ii*) that the costing organisation should be conversant with technical aspects of the work, to detect flaws in the original data and to offer constructive criticism to improve efficiency ;

(*iii*) that promptitude and utmost regularity in the supply of data to the organisation should be ensured ; and

(*iv*) that where the availability of actual data is not possible in time, best approximation should be made and subsequently corrected.

5.21.2. To secure the best results, it is desirable that the cost organisation should work under a competent Cost Engineer assisted by a trained staff. The Cost Engineer should be able to comment on, (*i*) the operations which are costing more than the estimates, (*ii*) the possible avenues of saving and, (*iii*) the total ultimate cost of the project. This organisation should be responsible to the Chief Executive of the project, who should, on the basis of the cost reports and comments, be able to take effective and timely measures to control the cost of the project.

5.21.3. Promptitude in cost reports is an important requirement of a successful control system. The Project Manager needs information that makes possible correction of conditions while the work is being performed. Whether report should be daily, weekly or monthly, will depend on the needs of a particular section of the project organisation. They must be simple, timely and up-to-date.

5.21.4. The success of cost department is largely dependent on the interpretation of operating results as determined from periodic cost reports which should clearly indicate whether variance is due to volume or labour costs. Control of physical standards which speak for themselves, is more valuable and it is our view that the Cost Accounting Section should lay greater emphasis on quantity engineering data than on rupee cost figures. Data related to labour output, plant output, material consumption account is more useful to the Engineers for the cost control and for framing a reliable basis for future planning and estimating. It, therefore, follows that estimates of physical quantities and performances if prepared in a form comparable with costing procedure would be helpful in establishing closer co-operation and understanding between the cost and operating departments and a greater recognition would result on the part of the cost section of the problems faced by the operating departments.

5.21.5. Certain assumptions would be essential to produce timely cost reports. Some of these are :—

(*i*) Provision for repairs and overhauls of special equipment. Assumptions and procedure of accounting has already been dealt with in Chapter 6.

(*ii*) Unpaid bills have to be accounted for cost purposes.

(*iii*) The procedure of pricing the stores should be based on "Standard Rates" so that articles may be priced immediately as they are issued. Need for reflection of current prices in cost figures is not so important in Civil Engineering Works.

5.22. Distribution of Cost

5.22.1. The distribution of cost relates to the assigning of expenditure, as represented by original documents such as pay rolls, invoices of the materials and supplies to each item of work in the same manner as

planned by the estimator. Intelligent cost distribution calls for a knowledge of the plan of construction, the purpose for which all labour and materials are used and construction methods followed in the field, besides a knowledge of construction accounting principles. This would emphasise the necessity of estimating and cost distribution adhering strictly to the standard classification of accounts.

5.23. Cost Reports

5.23.1. In developing the usefulness of the cost reports different classes of executives and their needs must be understood and recognised. Junior executives (Overseers) who are concerned with details of every day operations should have detailed reports in order to enable them to control cost. These men are in close contact with expenditure primarily for labour and materials on operations under their charge and with the daily output. The costing section and on small projects the overseers themselves, should be able to produce daily the cost per unit of physical quantities or structural quantities on the type of work under costing. These reports should help these Junior Executives to control wastes of all kinds by control on the activities of operators and machines placed under their charge. The scope of these reports is necessarily limited but these reports form the foundations of costing system and cost control. We may call the reports at this level as "Daily Output Reports".

5.23.2. Executive Engineers who have the overall responsibility for functions entrusted to them exert their influence on costs and operating results have to adapt the work to overall conditions of a project and find solutions for factors which retard output. By comparing actuals with estimated costs, variations are obtained which are analysed in the reports and causes. The Project Manager can thereby know the efficiency of men and machines on the job.

5.24. Field Report and Records

5.24.1. The Cost Section would require the following:—

(*i*) Daily pay rolls and acquittance rolls with output report.

(*ii*) Daily 'materials' report received, issued, and on hand.

(*iii*) Daily equipment performance report.

5.24.2. The reports may be prepared by Assistant Executive Engineers, Foremen, Time-keepers or Clerks but should preferably be seen and signed by the Executive Engineer. In addition to this, each official should maintain a daily diary in which all essentials regarding the work under him are recorded. Similar weekly consolidated reports should be

prepared for the Chief Engineer's office if it be other than the Project Manager. Monthly consolidated reports ought to be prepared for the Government.

5.25. Pay Rolls and Acquittance Rolls

5.25.1. Briefly speaking, we have recommended adoption of a Time-keeping system on the lines of the one used at Bhakra, the introduction of a Daily Time Card prepared by each Foreman, Labour Ledgers and Identity Cards, each carrying a photograph of the worker.

5.25.2. The time of men on construction work cannot be distributed with the same accuracy as for a workman at a bench or machine all day, probably working on only one operation. It is not difficult, however, for a foreman to keep distribution of each man's time to the nearest quarter or half an hour, and this is the greatest accuracy necessary. Even to the nearest hour is generally sufficient, as in the end inaccuracies will balance each other.

5.26. Daily 'Materials' Report

5.26.1. The recommendations are that Stores Receipt Books and Stores Issue Books should replace measurement books and so far as the receipt and issue of stores as are concerned the Bin Cards and Stores Ledgers should be used instead of the Register of Daily Stock Receipt and Issue, ½ yearly balance return of stock and ½ yearly register of stock.

5.26.2. The collecting and recording of materials' costs will be done in the main office and checked against foreman's field reports.

5.26.3. Except for violent fluctuation in the market, prices of any principal commodities, prices of stores be kept fixed for the duration of the project. Any losses or gains on stores during the year should be adjusted by debits or credits to work at the end of the year. It is, therefore, simpler to report in most cases, the total work performed to the end of the week or month, leaving it to the office to determine individual weekly or monthly progress by deducting the quantities in the previous report from these in the last report.

5.27. The Collecting and Recording of Machine Costs

5.27.1. Although mechanical equipment has been used in this country on large projects during the last century, it was being done on a comparatively small scale. Machines, however, play a very important role in the present day projects and cost colossal amounts. A proper system of collection of field data and its processing in the office is, therefore, very necessary for the well being of the project.

5.27.2. The Cost Section should maintain an "Equipment Register" in form N-25 which will provide information regarding the type of equipment, equipment number, from whom purchased and data of purchase, size, capacity, original cost and a record of use rate/hr. or ownership cost/hr. The record should show the estimated economic life of machines and their cost from which the depreciation rate is determined to which a percentage for repairs and overhauls is added in tune with the recommendations in Chapter 3. This will ensure ownership cost record of all equipment on the job.

5.28. DAILY REPORT

5.28.1. Daily reports show the work done during the day. It is easy to report because the Foreman or Time-keeper knows the number of the units performed during the day and where the work started and left off.

5.29. DAILY REPORT FORMS

The following forms are recommended :—

5.29.1. Daily Time Check Sheet (Form No. 5.29.1.) gives at a glance the result of checking of the labour by the Time-keeper during the working hours.

5.29.2. Daily Equipment Report (Form No. 5.29.2.) gives the No. of hours each machine worked on a particular job.

5.29.3. Materials and Stores issued to any Foreman during the day are reported by the Foreman on Form No. 5.29.3.

5.29.4. Details of field repairs carried out on any machine during the day appear on Form No. 5.29.4.

5.29.5. Daily accident and breakdown report appears on Form No. 5.29.5.

5.29.6. Daily report for the use of automobiles is given in Form No. 5.29.6.

5.29.7. Daily output report for machine is given on Form No. 5.29.7.

5.29.8. Daily Mass Concrete Report is sent on Form No. 5.29.8.

5.29.9. Report on misc. items of work, *e.g.* laying and vibrating, form-work and creation, cleaning and curing, finishing etc., are made on Form No. 5.29.9.

5.30. Units of Daily Measurement of Work

5.30.1. The units of measurement of work done should be the same as those allocated for preparing the estimates. The kind and amount of information required for determining unit costs will depend on the nature of the work. On heavy masonry work such as dams and dock walls, it will be necessary to know the C.F.C. (hundred cubic feet) of concrete poured or masonry executed or the square feet of forms placed.

5.30.2. The following units are suggested for reporting work performed daily on several accounts :—

Account	*Approximation unit of measure*
1. Mechanical excavation	Number of loads (Cubic Yds).
2. Hand excavation	Lin. ft. of trench, No. of footing.
3. Hauling aggregate and Steel hauling cement.	Number of loads. Number of sacks.
4. Form-work Footings.	Number completed.
Columns. Walls. Beams & Girders.	Lin. feet of wall or No. of panels. Lin. feet of wall or No. of panels. No. of completed or Lin. ft. or bays.
Slabs Sills.	No. of bays. No. of windows.
5. Concreting.	No. of sacks of cement for each class of concrete, or by No. of batches produced.
6. Exterior curation walls.	No. of bays.
7. Bearing walls and Partitions.	No. of tiles or bricks or Lin. ft. × height or No. of sacks of lime or cement.
8. Plastering.	No. of sacks of plaster. No. of rooms.
9. Carpentry-posts, Joists, Rafters etc.	No. of pieces. No. of days or sq. ft. of area.
10. Flooring and Roofing.	No. of days or sq. ft. of area.
11. Structural Steel.	No. of days or sq. ft. of area.

5.31. Accuracy Required

5.31.1 The time of a man on construction work cannot be distributed with the same accuracy as for workman at a bench or machine all day, probably working on only one operation. It is not difficult however, for a foreman to keep distribution of each man's time to the nearest quarter or half an hour, and this is the greatest accuracy necessary. Even to the nearest hour is generally sufficient, as in the end inaccuracies will balance each other.

5.32. Monthly Reconciliation

5.32.1. Monthly reconciliation of figures of work and expenditure between Costing and Accounting Sections is most essential. The daily measurements of works on the basis outlined in para 5.30.2. give only the approximate results, which are good enough for executing daily check of the performance of the equipment and operations. For working out the unit rates, however, all measurements of works have to be taken into account on a specified day towards the end of the month, and furnished simultaneously to the Costing and Accounting Sections. To bring about reconciliation between figures for expenditure in two sections, those relating to the accounting side are brought up-to-date by taking into consideration the unliquidated liabilities, adjustments awaiting acceptance etc. This reconciliation should also cover Store Accounts and Workshop Accounts.

5.33. Weekly Equipment Use Report

5.33.1. On large Projects using a big fleet of machines, the Project Manager should be kept posted as regards the machines working, lying idle or under repairs. A weekly chart showing these details is given in Annexure 14.

5.34. Cost Schedule

5.34.1. The costing is the reverse of the process of Estimating described in para 5.5. Typical charts and graphs for Mass Concrete, Mixed Plant, Form-work, and total executive force, are shown in Annexures 11, 12 and 13, such charts should enable the Project Manager to lay his fingers exactly on the pulse and take timely action.

5.35. Progress Reports

5.35.1. Monthly Progress Reports are necessary to keep the Project Manager and the State and Central Authorities informed of the actual progress of work, the actual cost, and the head of cost. It should be the responsibility of the Costing Section to furnish such reports punctually on the Forms shown in Annexure 8, 9 and graphically in a Annexure 18.

5.35.2. Form No. in Annexure 16 gives the figures by quantities and items of work.

5.35.3. Form No. in Annexure 17 gives the figures by expenditure on each item of work.

5.36. MONTHLY VARIATION STATEMENT

5.36.1. The Monthly Progress Reports mentioned above should enable the Project Manager to judge whether the quantities of various items of work and their rates of cost are behaving, whether any or both of these show a tendency to run away from the estimated figures and what is likely to be their effect on the ultimate cost of the work. The Project Manager should submit a half yearly review on the effects of variations on the ultimate cost of project with a view to enable to the higher authorities to decide, administrative approval is necessary.

5.36.2. A sample form for such forecast is given in Annexure 18.

EXCAVATION, LOADING, HAULING AND COMPACTION UNITS

6.1. Excavation, Loading, Hauling and Compaction Units

6.1.1. *Introduction.*—This chapter deals with the outputs, hourly use-rates and the unit rates of the earthwork by mechanical equipment, *viz.* (*i*) Shovels (*ii*) Draglines (*iii*) Rooters (*iv*) Dozers (*v*) Drawn Scrapers (*vi*) Motorised Scrapers (*vii*) Belt-loaders (*viii*) Dumper Trucks (*ix*) Motor-graders and (*x*) Sheepsfoot Rollers.

6.2. Outputs and Production Rates, Working Hours and Operating Efficiency

6.2.1. The working hour forms have been adopted for the basis of calculations, for the reasons already given. The actual productive time is less than 60 minutes in a working hour. On an average 10 minutes are taken as lost per hour in minor breakdowns, and a 50-minute hour is the accepted practice. The average production obtained in a working hour is governed by operating efficiency which is a function of the Job and Management factors. The Job factor is governed by the physical conditions of the job *e.g.* topography, working space, the surface, weather conditons and specifications. The Management factor covers conditions which pertain to the efficiency of operation and constitute items such as (*i*) selection, training and direction of men (*ii*) selection, care and repairs of equipment (*iii*) planning, laying out of the job, supervision and co-ordination of the operations. A table prepared by Frank A. Nikirk of U.S.A., after many years of critical study and research, is reproduced below :—

TABLE 6.2.1.

Job Factor	Management Factors			
	Excellent	Good	Fair	Poor
Excellent	0.84	0.81	0.76	0.70
Good	0.78	0.75	0.71	0.65
Fair	0.72	0.69	0.65	0.60
Poor	0.63	0.61	0.57	0.52

6.2.2. A certain amount of scaling down in job and management factors is necessary in our case so long as we have to depend on foreign imports for machines and their spare parts, and there is somewhat still a dearth of skilled personnel in our country. We have, therefore, modified the above table as shown below and adopted the mean figure 0.65 for average operating efficiency in our calculations, as given below:—

TABLE 6.2.2.

Job Factor	Management Factors		
	Good	Fair	Poor
Good	0.75	0.71	0.65
Fair	0.69	0.65	0.60
Poor	0.61	0.57	0.52

6.3. Shovels and Draglines

6.3.1. The Peak Production

The peak production of a shovel or a dragline is a function of the depth of the cut, the angle of the swing, the bucket efficiency and the standard production. The standard or peak production means the rated capacity of the bucket divided by the cycle time of the shovel or dragline for a 90° swing and the optimum depth of cut. It is the basic production for ideal conditions without taking into account any of the factors affecting the output. The depth of cut is the optimum when the dipper comes up with a full load without undue crowding and the output is the greatest. The bucket efficiency is the ratio of the volume (Borrow-pit Measure) handled in one bucket load to the rated volume of the bucket ; this depends on the swell characteristics of the soil.

6.3.2. As it is not always possible to predict the exact values of the angles of swing and depths of cut we have for estimating purposes adopted the optimum depth of cut and 90° swing in our computations.

6.3.3. The Power Crane Shovel Association of U.S.A. have quoted the following Tables 6.3.3. (*i*) and 6.3.3. (*ii*) giving the peak productions of shovels and draglines as adopted by Nikirk. The outputs are obtained by assuming the optimum depth of cut, 90° angle of swing, 60-minute

a working hour, the materials being loaded into proper sized hauling units.

TABLE 6.3.3.(*i*)

Rated output of shovels in CFC units per min. hr., optimum depth of cut and 90° swing

Sl.No.	Type of soil	Shovel dipper capacity in C. yd.					
		3/4	1	1½	2	2½	3½
1.	Moist loam or slight sandy clay.	45	55	77	96	109	142
2.	Sand and gravel.	42	54	73	89	105	136
3.	Good Common earth.	36	47	65	81	96	123
4.	Clay hard and tough.	30	39	57	72	84	109
5.	Rock, well blasted.	26	34	49	62	74	99
6.	Clay, wet sticky.	19	26	39	50	62	84
7.	Rock, poorly blasted.	14	20	31	43	53	73

TABLE 6.3.3.(*ii*)

Rated output of dragline in CFC units per 60 *min. hr., optimum depth of cut and* 90° *swing*

Sl. No.	Type of soil	Shovel dipper capacity in C. yd.					
		3/4	1	1½	2	2½	3
1.	Light moist clay or loam.	35	43	59	72	82	105
2.	Sand and gravel.	34	42	57	69	80	103
3.	Good common earth.	28	36	51	62	72	92
4.	Clay, hard and tough.	24	30	43	53	62	82
5.	Clay, wet and sticky.	15	21	30	39	47	66

Average job production for a 50 min. hr., and 65% operating efficiency is tabulated blow in Table 6.3.4. (*i*) & 6.3.4. (*ii*).

TABLE 6.3.4. (*i*)

Job Production of shovels per working hour at 65% efficiency in CFC units Borrow-pit Measurement

Sl. No.	Type of soil	Shovel dipper capacity in Cu. yd.					
		3/4	1	1.½	2	2.½	3
1.	Moist loam or light sandy clay.	24	30	42	52	58	77
2.	Sand and gravel.	23	29	40	48	56	73
3.	Good common earth.	19	25	35	44	52	66
4.	Clay, hard and tough.	16	21	30	39	45	58
5.	Rock, well blasted.	14	18	26	34	40	53
6.	Clay, wet and sticky.	10	14	21	27	34	45
7.	Rock, poorly blasted.	8	11	17	23	29	40

TABLE 6.3.4.(*ii*)

Job Production of Draglines per working hour in CFC units Borrow-pit Measurement.

Sl. No.	Type of soil	Dragline dipper capacity in Cu. yd.					
		3/4	1	1.1/2	2	2.1/2	3
1.	Light moist clay or loam.	19	23	32	39	44	57
2.	Sand and gravel.	18	23	31	37	43	55
3.	Good common earth.	15	20	27	34	39	49
4.	Clay, hard and tough.	13	16	23	29	34	44
5.	Clay, wet and sticky.	8	11	16	21	25	35

6.3.5. These recommendations for output tally very closely with the actual outputs obtained on some of our projects, are given below. The recommendation of some standard authorities abroad is shown in appendix 6.

TABLE 6.3.5. (*i*)

Comparative Statement of cutput of shovels per hour in CFC unit (Borrow Measure)

Sl. No.	Projects	Soil	Output per hr. in CFC		Remarks
			Project actual	R & C.C.	
1.	3.½ Cyds. *Shovel*				
a.	Nangal Hydel Channel	Light clay mixed with gravel.	51.7	58	Soil is taken as clay hard & tough.
b.	Hirakud	Semi-pervious	47*	58	Soil is taken as murum. *Embankment measure is 51.82 and the borrow measure is calculated.
2.	2.½ Cyds. *Shovel.*				
a.	Bhakra	Rock	37*	40	*Worked out from
		Earth Claystone & Rock	24.8*	29	the register of work for electric shovel assumed as rock poorly blasted.
b.	Nangal	Light clay with gravel	42	45	Murum assumed
		Hard clay	30	45	
c.	Hirakud	Semi pervious	37	45	
d.	Maithon	Earth : Rock as 2 : 1	37	72	
3.	1.½ Cyds. *Shovel.*				
a.	Hirakud	Semi-pervious	21	30	Murum assumed.

TABLE 6.3.5. *ii*

Comparative statement of output of Draglines in CFC units (Borrow) per hou

Sl. No.	Project	Soil	Output CFC per hr.		Remarks
			Project	R. & C.C.	
1.	$3\frac{1}{2}$ *Cyds.*				
a.	Tungabhadra (Andhra)	Shishy soft black cotton soil	39	35	Soil taken as clay wet and shishy
2.	$2\frac{1}{2}$ *Cyds.*				
a.	Harike	Earth	40.6	39	
b.	Sarda Hydel	Wet earth Sandy soil	25	25	
c.	Tungabhadra (Andhra)	Shishy soil	28	25	
3.	$1\frac{1}{2}$ *Cyds.* Tungabhadra (Andhra)	Shishy soil	20	21	
4.	1 *Cyd.* Harike	Earth	19.5	20	
5.	3/4 *Cyds.*				
a.	Harike	Earth	14	15	
b.	Tungabhadra (Andhra)	Stiff black cotton soil	11	13	

6.4. Rippers and Rooters

6.4.1. Rippers and Rooters enable considerable economy in the breaking up of materials prior to dozing scraping etc. as well as in breaking or clearing out roots etc. in land clearance. Field observations show that the use of Ripper or Rooter prior to scraping shows fair increase in output. Another primary benefit is the reduced strain and wear on tractors and scoops resulting in a saving in fuel consumption and in better pay-loads. A Ripper or Rooter will break enough material to keep 3 to 6 tractors and scrapers employed. Field observations reveal that 1 hour of ripping may yield sufficient loosened dirt to keep a dozer employed from 4 to 15 hours.

6.4.2. In very hard soils it may be necessary to rip and then to cross-rip. In this case the output figures corresponding to the particular ripping width and depth and tractor speed should be halved to make allowance for this double work.

6.4.3. The depth of rooting depends upon the following factors :—

(a) The design and size of the rooter which varied from 1′ to 2′-6″.

(b) The size of the tractor—usually a tractor not smaller than 90 BHP is used.

(c) The nature of the soil which will vary from hard tough clay to cemented conglomerate of disintegrated rock.

(d) The number of twines used.

Sometimes a pusher tractor is added to assist the pulling tractor in rocky compacted materials.

Rooting is generally done in the first gear. The speed at governed R.P.M. in different gears and the draw-bar pull of 130 H.P. tractor are given below :—

TABLE 6.4.3.

Draw bar pull and speed of 130 *H.P. tractor*

130 H.P. Tractor. Gear	Speed at governed R.P.M.	Draw-bar pull (lbs.)
1st	1·6	29,900
2nd	2·3	21,700
3rd	2·9	15,700
4th	3·7	11,900
5th	4·8	8,600

6.4.4. The following table indicates the nature of duty that may be expected from a heavy rooter.

TABLE 6.4.4.

Performance of rooters in different types of soils

Sl. No.	Nature of soil	No. of twines	Width at each rooting	Depth in feet	No. of turns reqd.	Pusher tractor reqd.
1	2	3	4	5	6	7
1.	Gravel & sand compact & cemented.	2 to 3	4 to 8	1 ft.	2 to 4	1
2.	Good common earth.	3	8	2 ft.	1	—
3.	Clay hard & tough.	3	8	2 ft.	1 to 2	—
4.	Murum.	2 to 3	4 to 8	1′-6″	1 to 2	Usually not
5.	Hard Murum.	2 to 3	4 to 8	1 ft.	2 to 4	1
6.	Clay with boulders.	3	8	1′-6″	1	—
7.	Clay wet & sticky.	3	8	1′-6″	1	—

6.4.5. Production by Rooters

Taking a travel speed of 1.6 m.p.h. and an operating efficiency of 65% (wide and extensive areas) the following production per working hour is obtained :—

TABLE 6.4.5.

Average output of Rippers in CFC Units (borrow measurement)

Sl. No.	Soil	Vol. rooted per hour
1.	Compact cemented gravel.	60-240
2.	Good Common earth.	1000
3	Clay.	500-1000
4.	Murum.	180-750
5.	Hard murum.	60-240
6.	Clay with boulders.	750
7.	Clay wet.	750

6.5. Dozers

6.5.1. Before starting earthwork on any project it is necessary to grub the ground and clear the area of trees, stumps and bushes. Frequently both clearing and grubbing are carried out in one operation by using a tractor dozer assisted by a rooter. The unit of measurement for grubbing and clearing site should preferably be the acre.

6.5.2. Stripping

This consists of removing the top vegetative soil to specified depths and where dirt is to be transported only a short distance say upto 200 ft. a tractor-dozer is used and for longer hauls a scraper. The unit of measuring stripping should be an acre although the C.yd. measure has been adopted on some of the projects. The size of the tractor required will depend upon the growth of jungle, the size of the boulders, the hardness of the soil and the terrain. Tractors smaller than 90 B.H.P. will generally be found unsuitable for this work.

6.5.3. The production of dozers will naturally vary with the field conditions. The following data may however be adopted in the absence of any experimental observations.

TABLE 6.5.3.

Production of Dozers for grubbing and clearing

Size of tractor	Area grubbed and cleaned per hr. (acres)		
	Favourable conditions	Average conditions	Unfavourable conditions
1. 90 BHP tractor with a dozer.	0.66	0.40	0.16
2. 130 BHP tractor with a dozer.	0.80	0.5	0.2

6.5.4. Some manual labour will be required to burn or remove the shrubs excavate out some stumps ; collect stray roots etc. After accounting for the manual labour, petty establishment etc. the unit rate for clearing and grubbing will work out as given below in table :—

TABLE 6.5.4.

Item	Unit rate for grubbing and clearing
Grubbing and clearing areas, to remove all shrubs, stumps, trees not exceeding 6″ in dia. boulders (not exceeding 2 C.yds.) and stacking them neatly in or outside the area so as to allow for a lead not exceeding 150 ft. including pitching up roots, branches, stumps and burning or otherwise, disposing off the wood, leaves etc. as directed.	
(a) Favourable working conditions.	Rs. 100 per acre
(b) Average working conditions.	Rs. 250 ,,
(c) Difficult working conditions.	Rs. 400 ,,

6.5.5. Dozer Outputs

Most jobs involve a number of strata *e.g.* a layer of top soil followed by a layer of common earth, followed by a sub-soil comprising clay and/or sand. Moreover a large portion is usually a mixture of one or more of the above. The thickness of each layer usually varies throughout the job.

Seasonal changes in moisture content also affect the volume change. Some materials will swell freely; others, like sand, will not. Thus any calculation of the number of dozer cycles, required to move a given volume of earth can only be approximate, as the time required will further vary according to (1) the condition of the tractors, (2) efficiency of the operators (3) weather conditions, (4) moisture content, (5) type of soil, and (6) rigidly of inspection and control of specification.

The following data in table 6.5.5. pertaining to the design of American machines will be helpful for estimating out-turn.

TABLE 6.5.5.

Dozer Capacity.

Sl. No.	Tractor H.P.	Blade width in feet.	Capacity in CFC.	Approximate wt. in lbs.
1.	130-160	11	0.85	5200
2.	85-100	10	0.65	4400
3.	65-75	8	0.51	2800

6.5.6. The following table 6.5.6. gives the output of dozers in "Good common earth" for a 50 minute working hour and 65% operating efficiency.

TABLE 6.5.6.

Job productions of dozer in good common earth (CFC Unit)

Size of tractor	Lead one way in feet								Remarks
	50 ft.		100 ft.		150 ft.		200 ft.		
	AD	BD	AD	BD	AD	BD	AD	BD	
130 B. H. P.	34	27	21	17	15	12	12	10	AD-angle dozer.
90 B. H. P.	30	25	18	16	13	11	10	9	BD-bull-dozer

Where the truck loads are to be pushed over the edge of a fill (Lead about 50 ft.) the production in earth may be taken as 1.4 time that given in table 6.5.6.

6.6. SCRAPERS

6.6.1. Use of Scrapers

Scrapers combine the actions of excavation and haulage. They are mostly adaptable to plowable materials. In non-cohesive sand or gravel, it is difficult to load scrapers as the material will not pile up into the scraper, and the pay-load is considerably reduced. Wet and muddy soils make the discharging of the scraper difficult. For efficient working material should be free-flowing with very little or no rock and shale.

6.6.2. Tractor-drawn scrapers and motorised scrapers are used to excavate and haul large volumes of earth for such projects as dams, levees, highways, airports and canals. Their use depends considerably on the job conditions and economic use. They are particularly well suited for canal excavation and embankments not involving hard rocky material and providing large hauling area. For short hauls of 500 to 1500 ft. the crawler type tractor, pulling a rubber-tyred, self-loading scraper is mostly used. The Crawler tractor has a high draw-bar pull for loading the scraper, has a good grip on the ground, can operate over muddy haul roads, but has a low travel speed the maximum being about 6 m.p.h. As a drawn scraper is a self-contained unit, its performance is better than that of other machines which have to depend upon another unit for loading *e.g.* an excavator, or a pusher tractor working with a motor-scraper. For longer haul distances of 1000 to 5000 ft. or more, the rubber-tyred tractor pulling a rubber-tyred self-loading scraper is more economical than the Crawler unit. While this motorized unit cannot deliver as great a tractive effort in loading the scraper as the Crawler type, it has a higher travel speed upto about 18 m.p.h. Usually a pusher tractor is used along with motorized units to facilitate easy scraping and thereby increase scraper outputs and cut down earthwork costs.

6.6.3. Equipment Combination

The following equipment combination in case of drawn scrapers will be generally found suitable for various types of soils.

TABLE 6.6.3.

Equipment Combination

Sl. No.	Type of soil	Tractor B. H. P.	Scraper struck capacity in Cyd.	Pusher Tractor. B. H. P.	Remarks
1	2	3	4	5	6
1.	Light loam or crumbly silt.	90	10 to 12	Not reqd.	—
2.	Good common earth or clayey loam.	90 or 130	12 to 15	-do-	—
3.	Sand and gravel.	-do-	10 to 12	90	—
4.	Murum.	130	15	130	Rooting desirable.
5.	Clay hard & tough.	130	10 to 12	90	-do-
6.	Hard Murum.	130	15	130	Rooting essential.
7.	Clay, with boulders.	130	15	130	-do-
8.	Clay, wet & sticky.	130	15	130	-do-

6.6.4. Speed of Hauling

The speed of hauling is a function of (*i*) the road resistance, (*ii*) B.H.P. to the weight ratio of the tractor, and (*iii*) grade resistance, due both to rolling resistance and grade resistance the speed on adverse grades goes down. The speed of 130 HP. D-8 Crawler tractors in 5th gear is 4.8. m.p.h. 4th gear 3.7, 3rd gear 2.9, 2nd gear 2.3 and 1st gear 1.6 m.p.h. In the case of motorized scraper, for example D-W 21 caterpillar scraper, the speed in 5th gear is 20.2 m.p.h., 4th gear 12.2, 3rd gear 7.2, 2nd year 4.2 and in 1st gear 2.2 m.p.h.

6.6.5. Time of Hauling

The time taken for the scraper to haul and return depends on the lengths of haul on the level and on the incline. As both these are variables differing from project to project, it will be reasonable to assume an average speed of haul which would cover the time gained on level grade when the machine goes at a greater speed than the average and that time lost while the machine is travelling at a lesser speed on the incline. In keeping with this assumption, we have adopted in our calculation an average speed of 4 m.p.h. in the case of drawn scrapers as they normally operate on short leads of about 500 to 1500 ft. and more on inclines. As motorised scrapers haul greater distances on level grades than that on inclines we have adopted an average speed of 15 m.p.h. in its case.

6.6.6. Lead

Lead is defined as the shortest practicable route and not necessarily the route taken actually to move the mass of the earth from one situation to the other.

We have adopted lead in terms of one way haul in feet and the cycle time in minutes as that required to haul and return through this distance plus the time taken in loading and unloading, turning, and changing gears.

6.6.7. Drawn scrapers

Fixed times are given below :—

TABLE 6.6.7.

Fixed time for Euclid-drawn Scrapers

Sl. No.	Type of loading	Working conditions	Cycle time for loading 15 cyd. struck scraper in minutes	Cycle time for loading 10 cyd. struck scraper in minutes
1.	Back track loading	Favourable	1.75	1.45
		Average	2.40	2.10
		Unfavourable	3.00	2.70
2.	Chain loading or shuttle loading.	Favourable	1.25	1.05
		Average	1.60	1.40
		Unfavourable	2.00	1.80

TABLE 6.6.8.

Cycle times and No. of trips for 50 min. hr. drawn scrapers

Sl. No.	Length of haul one way in Liner feet	Cycle time minutes	No. of trips in 50 mts.	Remarks.
1.	500	4.7	10.6	
2.	600	5.0	10.0	
3.	800	5.5	9.1	Fixed time 2.25 minutes for loading & unloading and 1 min. for turns etc. Cycle time includes also return time. Average speed 4 mph.
4.	1000	6.0	8.4	
5.	1200	6.6.	7.6	
6.	1600	7.5	6.7	

6.6.9 Swell Factor

The pay-load of a scraper is affected by the swell characteristics of the soil. The swell factor is equal to 100 divided by (100 plus per cent of swell). The following table 6.6.9. has been drawn up with reference to the figures *vide* 'Estimating Production and Costs' by Euclids.

TABLE 6.6.9.

Values of Swell and Swell factors of Soils

Sl. No.	Soil	Percent of Swell	Swell factor (natural)	Swell factor for scrapers.
1	2	3	4	5
1.	Light loam or Crumbly silt.	20	0.83	0.93
2.	Sand and gravel,	18	0.85	0.95
3.	Good common earth or clay loam.	25	0.80	0.90
4.	Clay, hard & tough.	33	0.75	0.85
5.	Hard murum.	18	0.85	0.95
6.	Hard murum.	33	0.75	0.85
7.	Clay, wet and sticky.	33	0.75	0.85

NOTE : Swell factor when loading scraper is more because of more compact loading.

6.6.10. Production rate

Taking average load as the mean of the heaped and struck capacity and the swell factor as in table 6.6.9. and the number of trips per working hour as in table 6.6.8. the job production in different type of soils in 50 min. working hour and 65% efficiency are tabulated below in table 6.6.10 (*i*) and (*ii*).

TABLE 6.6.10. (*i*)

Job production in light loam

Sl. No.	Length of haul one way in feet	130 BHP Tractor drawn 15/20 Cyd. scraper	90 BHP Tractor drawn 10/12.5 Cyd. scraper	Remarks
1	2	3	4	5
1.	500	30*	19	
2.	600	28	18	
3.	800	26	17	
4.	1000	24	16	
5.	1200	22	14	
6.	1500	19	12	

* $\frac{17.5 \times 27 \times 0.93 \times 10.6 \times 65}{100 \times 100}$ is equal to 30.
10.6. No. of trips in 50 min.
0.65 Efficiency factor.
17.5. is the average capacity
27 is a multiplier to convert cyds. into CFT.
0.93 is the Swell factor

TABLE 6.6.10. (*ii*) (*a*).

Sl. No.	Soils	Output in CFC Borrowpit Measure 15/2 cyds. Scraper (Lead one way haul in feet)					
		500	600	800	1000	1200	1500
1.	Light loam or crumbly silt.	30	28	26	24	22	19
2.	Sand & gravel.	31	29	27	25	22	19
3.	Good common earth.	29	27	25	23	21	18
4.	Clay, hard 5 & tough.	28	26	24	22	21	18
5.	Murum.	31	29	27	25	22	19
6.	Hard murum.	27	26	24	22	20	17
7.	Clay, wet and sticky.	27	26	24	22	20	17

TABLE 6.6.10. (*ii*) (*b*).

10/12.5. *Cyds. scrapers.*

1.	Light loam or crumbly silt.	19	18	17	16	14	12
2.	Sand & gravel.	19	18	17	15	14	12
3.	Good common earth.	18	17	16	15	14	12
4.	Clay, hard & tough.	18	17	16	15	13	11
5.	Murum.	19	18	17	16	14	12
6.	Hard murum.	17	16	15	15	13	11
7.	Clay, wet & sticky.	17	16	15	15	13	11

6.6.11. **Motorised Scrapers:—** Cycle Time

TABLE 6.6.11.

Cycle time and No. of trips per 50 min. hr.

Sl. No.	Length of haul one way in Linear feet.	Cycle time in minutes	No. of trips in 50. Min. Hr.	Remarks
1.	1000 ft.	4.0	12.5	
2.	1500 ft.	4.4	11.4	
3.	2000 ft.	4.8	10.4	Fixed time nearly same as that of drawn scrap is 2.25 at loading & unloading & 1 min. for turns etc.
4.	2500 ft.	5.2	9.6	
5.	3000 ft.	5.5	9.1	
6.	4000 ft.	6.3	7.9	
7.	5000 ft.	7.0	7.1	Average speed 15 m.p.h.

6.6.12. Production rate of Motorised scrapers

Job production on the basis of 50 minhr. and 65% efficiency, taking the average load as the mean of the heaped and struck capacity is the swell factor as given in table 6.6.9. and the number of trips per working hours as in table 6.6.11. has been worked out in table 6.6.12. (*i*) & 6.6.12 (*ii*).

TABLE 6.6.12.(*i*)

Job production of Motorised scrapers

(*i*) 15/20 *Cyds. Capacity.*

Sl. No.	Soil	Output in CFC (Borrow Measurement) (One way haul in linear feet)						
		1000	1500	2000	2500	3000	4000	5000
1.	Light loam.	36	33	30	27	26	23	20
2.	Sand & Gravel.	37	34	31	28	27	23	20
3.	Good common earth.	35	32	29	26	25	22	19
4.	Clay, hard & tough.	34	31	28	25	24	21	17
5.	Murum.	37	34	31	28	27	23	20
6.	Hard murum.	33	30	27	25	24	21	18
7.	Clay, wet & sticky.	33	30	27	25	24	21	18

TABLE 6.6.12 (*ii*)

(*ii*) 10/13 *Cyds. Capacity.*

1.	Light loam.	23	21	20	18	17	15	13
2.	Sand & Gravel.	23	21	20	18	17	15	13
3.	Good Common earth.	22	20	19	17	16	14	13
4.	Clay, hard & tough.	21	20	19	17	16	14	12
5.	Murum.	23	21	20	18	17	15	13
6.	Hard murum.	21	19	18	16	16	14	12
7.	Clay, Wet and sticky.	21	19	18	16	16	14	12

6.7. Belt-Loader

6.7.1. Belt-loader is an excavating and loading unit. It excavates loose material, elevates and loads it into vehicles. Rarely it is used to cast the excavation directly. Its economic use largely depends on the adequacy of transporting units. It is pulled by a tractor. It has a cutting edge which excavates the material which in turn is picked up by a moving belt so aligned that a constant flow of material travels up the belt and is discharged into the hauling unit. It has the advantage of less loading time and constant discharge of material. But it is suitable and economical under the following conditions :—

(*i*) Where very high hourly production rate is required.

(*ii*) Where soil is free from rock.

(*iii*) Where uniform long and wide borrow pits exist.

(*iv*) Where a large quantity of earth is handled.

(*v*) Where loading conditions are such that from five to ten loads of free flowing material may be obtained between loader turn arounds and that is relatively long and level.

The loading time of the loader will be about 0.6 to 0.8 minutes under average conditions ; but it is not related to production figures as the latter depends on the adequacy of hauling units of proper size.

6.7.2. Assuming that properly matched equipment is made available, the output of a 54 inch belt-loader for 60 minute hour is as given below:—

TABLE 6.7.2.

	Working conditions			Remarks
	Favourable	Average	Unfavourable	
Production in CFC units per hour borrow-pit measurement.	270	202	135-95	54-inch belt 60 min-hr.

For a 50 min. hour and operating efficiency of 65% the average job production of belt-loader will be as under :—

TABLE. 6.7.2. (*i*)

Average Job Production of Belt-loader

	Working Conditions			Remarks
	Favourable	Average	Unfavourable	
Production in CFC units per hour borrow-pit measurement.	145	110	73-51	54-inch belt 50 min-hr. efficiency 65%

6.7.3. The auxilliary equipment required to obtain the outputs depends on the nature of the soil handled by the loader. In hard clays two pulling tractors or one pulling tractor and one pusher will be required in addition to rooting. A dozer constantly attending to levelling the borrow floor improves the operating efficiency and reduces wear and tear on the machines.

The combination of equipment required for different types of materials is indicated below in table 6.7.3.

TABLE 6.7.3.

Equipment combination Belt-loader operation

Sl. No.	Soil	Machinery Combination				Remarks
		Belt-loader	Touring tractor	Rooter	Dozer	
1.	Light loam.	1	1	—	—	
2.	Sand & Gravel.	1	1	—	—	If compact, 2 touring tractors, 1dozer & 1 rooter are required to give good output.
3.	Good common earth.	1	2	—	1/2	
4.	Clay, hard & tough.	1	2	1	1	
5.	Clay, wet & sticky.	1	2	1	1	Rooter useful for letting the soil dry before loading.
6.	Soft murum.	1	2	1	1	

6.8. Dumpers

6.8.1. The two types of dumpers commonly used on the projects are the rear dump and the bottom dump. Each type has its own advantage and use, depending on the job conditions. Dumpers can run on rough ground or on open wet sites unsuitable for lorries. Their economic length of haul is upto $1\frac{1}{2}$ miles lead.

6.8.2. Rear dumpers are specially designed to haul heavy materials like rock, one shale or a combination of free flowing and bulky materials and to withstand severe loading impact as it occurs in loading under a large shovel. They have maximum grade ability and can do rapid spotting in a restricted area.

6.8.3. Bottom dumpers are of a tractor trailer type and are largely used for hauling free-flowing materials such as loose sand and gravel, hard clay, broken shale etc. where dumping is unrestricted and the long adverse grades do not exceed 3% to 5%. They have a high manoeuvrability and a fast movement.

6.8.4. Rating of Dumpers

Usually dumpers are rated according to their capacity in struck measure, in heaped measure (generally 3 to 1 slope) and in terms of pounds of pay-load. It is important that not only the capacity in cu. yards but also in weight should be considered while considering the dumper capacities.

6.8.5. Production Rate—Cycle time

The production rate of dumpers or any hauling units varies with the length of the haul, load grade and road conditions *i.e.* on the Cycle time in general. Time required for loading, dumping or unloading, turning and spotting constitutes the 'fixed' time while the haul and return times are 'variable'. The 'fixed' time constants pertaining to Euclid dumpers are tabulated in table 6.8.6. An average haul speed of 12 m.p.h. in case of rear dumps and 15 m.p.h. in case of bottom dumps can be taken to work out the hauling and returning time for different leads.

TABLE 6.8.6.

Turning, Dumping and Spotting times for various job conditions

Sl. No.	Conditions	Rear Dump		Bottom Dump	
		Turn and dump in minutes	Spot in minutes	Turn and dump in minutes	Spot in minutes
1	2	3	4	5	6
1.	Level ground ample space, dumping in transit	1.5	0.15	0.7	.15
2.	Limited space, and some manœuvering.	2.0	0.30	1.0	0.50
3.	Constructed spaced manoeuvering to dump required	2.5	0.50	2.0	1.00

6.8.7. Outputs

The output of a dumper is directly related to the loading unit and the number of trips per hour. Generally, the capacity of the dumper should be 4 to 5 times that of the shovel or dragline. The material carried will have the swell factors as given in table 6.6.9. The swell factors in case of rock well-blasted is 0.57 and for shale or soft rock it is 0.75. An operating efficiency of 65% can be adopted in working out the output.

6.9. Shaping and Compacting Earthwork

6.9.1. This work is usually carried out by using a motorgrader or a bulldozer for spreading the soil a tractor-pulled sheeps, foot-roller for compaction and a sprinkler truck for adding water where the natural moisture content is less than that required.

6.9.2. Graders

Two types of graders are used ; the towed grader and the self-propelled. The towed grader is used where considerable force at low speed is desired as in ditching. The motorgrader is self-propelled and is designed for higher speeds in light work such as road maintenance and mixing of materials. It is generally gas or diesel powered with a 12 ft. wide hand controlled or motorised wide blade.

On an average a motorgrader operates at 2 m.p.h. and can cover an effective blade width of about 8 ft. Its output is expressed in terms of the area in 8. ft. covered by its blade in an hour.

6.9.3. Sheeps-foot Rollers

Sheeps-foot rollers are universally used for developing suitable compaction on rolled-fill dams. They are suitable for use in soils free from large boulders and they compact plastic soils better than any other mechanical method and for compacting the fill.

6.9.4. They are usually assembled in units of 1, 2, 3 or 4 drums. The tamping feet on the drums which are staggered, distribute the weight of the drum and give better tamping effect. The weight of a single drum varies from about 2700 lbs. to 3470 lbs. as empty, depending on the size and the number of tamping feet on the drum. Provision is usually made for filling the drum with liquid and/or sand in order to add to its weight. The optimum tractor speed for the use of a sheeps foot roller is approximately 2.5 m.p.h.

3.9.5. Average hourly output

The following hourly outputs in CFC units of borrowpit measure can be attained in a working hour (50 min.-hr.) with average operating efficiency of 65% in ordinary soils.

TABLE 6.9.5.

Average output of Sheeps-foot rollers

No. of Dumps	1×1				1×2				1×3			
No. of trips	6	8	10	12	6	8	10	12	6	8	10	12
Depth of layer												
4″	27	20	17	14	57	44	37	28	84	65	54	44
6″	40	30	23	20	87	65	50	44	13	97	76	65
8″	55	40	34	27	120	87	72	57	18	130	110	87
10″	67	53	40	34	144	107	85	72	220	163	130	110
12″	80	62	53	40	173	132	107	85	260	200	163	130

6.10. Use Rates of Earth-moving Equipment

6.10.1. In working out their use rates, we have assumed that the equipment is all new, that depreciation follows the straight line law and that the working hours form the basis of depreciation for all rated equipment. Maintenance and repair charges have been determined from table 3.12.3. while the fuel consumption has been taken from the formula : $0.5 \times \text{BHP} \times 6/8.26$ which gives the optimum consumption for a 60 min. working hour. We have adopted 65% or 2/3rd of the figure given by this formula for actual consumption, the wages operators and unskilled labour have been taken as those recommended by us.

6.10.2. The detailed analysis of the use rates are given in Appendix 7 and an abstract of the same is furnished below :—

TABLE 6.10.2

Hourly use rate of Mechanical Equipment

Sl.No.	Equipment		Hourly use rate in rupees
1	2		3
I.	*Belt-loader*	(H.P.)	
	18 B.V.Belt Loader 54″ width	·248	55.0
II.	*Dump track*		
	(a) 9.7 Cyd. 15 tons Rear Dump	150-165	34.0
	(b) 14.8 Cyd. 22 tons Rear Dump	250	52.0
	(c) 13 Cyd. struck Bottom Dump	200	37.0
	(d) 17 Cyd. ,, ,, ,,	260	47.0
III.	*Excavators*		
	a. (i) ¾ Cyd. Shovel	80	31.0
	(ii) 1½ ,, ,,	170	50.0
	(iii) 2½ ,, ,,	200	64.0
	(iv) 3½ ,, ,,	225	39.0
	b. (i) ¾ Cyd. Dragline	80	29.0
	(ii) 1½ ,, ,,	170	43.0
	(iii) 2½ ,, ,,	200	55.0
	(iv) 3¼ ,, ,,	225	74.0
IV.	*Scrapers*		
	a. 10/12.5 Cyd. Drawn Scraper	—	14.0
	b. 15/20 ,, ,, ,,	—	20.0
	c. 10/13 ,, ,, Motorised	176	43.0
	d. 15/20 ,, Motorised	225	56.0
V.	*Tractors*		
	a. 81 HP Crawler Tractor	81	25.0
	b. 130 HP ,, ,,	130	29.0
	c. 81 HP Tractor Dozer	81	28.0
	d. 130 HP ,, ,,	130	32.0
	e. D-4 Tractor with Sheepsfoot Roller	44	15.15
VI.	*Motor Grader*		
	115 H.P.	115	25.0

6.11. Unit Rate of Earthwork by Mechanical Means

6.11.1. The unit rate of earthwork involves the cost of excavation, transportation and compaction of a CFC of soil as measured at the borrow-pit. We have adopted the borrow measure in preference to the embankment measure as it is more precise. In the case of scrapers, however, borrow measurements are not always practicable and the volume of work done is calculated from the loose measure after applying the swell factor of the soil.

6.11.2. Most of the excavation work on projects is done by shovels and scrapers, although use of tractor dozers for dozing is considerable. In fact, a tractor dozer is a versatile unit performing many tasks *e.g.*, clearing, shipping, opening up cuts, dozing, push loading, back filling, etc. Draglines are mostly used on canal works. We have, therefore, confined our study of the earthwork rates by shovels and scrapers.

6.11.3. Using 1/3 hr. dozer per shovel the tables 6.11.3. (*i*) and (*ii*) give the rates per unit of shovelling.

TABLE 6.11.3. (*i*)

Cost per hour of working shovels with tractor dozer

Sl. No.	Shovelcu yds	Average Conditions			Rock work	
		Rate per hour		Total	Extra provision of 10% for repairs	Total rate per hour.
		Shovel	Tractor dozer 1/3rd			
1.	$\frac{3}{4}$	Rs. 31	Rs. 10	41	Rs. 4.1	Rs. 45
2.	$1\frac{1}{2}$	Rs. 50	Rs. 10	60	Rs. 6.0	Rs. 66
3.	$2\frac{1}{2}$	Rs. 64	Rs. 10	74	Rs. 7.4	Rs. 81
4.	$3\frac{1}{2}$	Rs. 89	Rs. 10	99	Rs. 9.9	Rs. 109

TABLE 6.11.3. (*ii*)

Cost of shovelling operation per CFC (Borrow measure) in different soils.

Sl. No.	Conditions	Size of shovels in cubic yards			
		3/4	1-1/2	2-1/2	3-1/2
1	2	3	4	5	6
1.	*Average Conditions* Hourly Use rate *vide* table 6.11.3.(*i*)	Rs. 41	Rs. 60	Rs. 74	Rs.99
	a. Moist loam or sandy Output CFC	24	42	58	77
	Rate per CFC	1.71	1.43	1.28	1.29
	b. Sand & Gravel Output CFC	23	40	56	73
	Rate per CFC	1.79	1.50	1.33	1.36
	c. Common earth, Output CFC	19	35	52	66
	Rate per CFC	2.16	1.71	1.43	1.50
	d. Clay hard & tough, Output CFC	16	30	45	58
	Rate per CFC	2.56	2.00	1.66	1.70
	e. Clay, wet & sticky, Output CFC	10	21	34	45
	Rate per CFC	4.10	2.88	2.19	2.20
	Rocky Conditions Hourly Use rate *vide* table 6.11.3.(*i*)	Rs. 45	Rs. 66	Rs.81	Rs. 109
	a. Rocks well blasted, Output CFC	14	26	40	53
	Rate per CFC	3.22	2.54	2.04	2.06
	b. Rock poorly blasted, Output CFC	8	17	29	40
	Rate per CFC	5.63	3.88	2.80	1.32

6.11.4. Analysis of Rate for rock work

Output of $2\frac{1}{2}$ Cyds. shovel per hour : 34 CFC.
Rear Dumper 9.7/11.4, average capacity : 10.5 Cyds.
Swell factor of blasted rock : 0.67
Borrow measure of 10.5 Cyds : $10.5 \times 0.67 \times 0.27$: 1.9 CFC.

Hauling cycle : Loading time plus hauling & returning time plus turning & dumping and spotting.

Loading time : $\dfrac{\text{Body capacity}}{\text{Shovel output per min.}} = \dfrac{1.9 \times 60}{34} = 3.4$ min.

Spotting time for truck : 0.3 min. (*vide* table 6.8.6.)

Average travel speed : 12 m.p.h.

Hauling and return time for 2000, 3000, 5000, 6000 and 8000 feet are 3.8, 5.7, 11.4 and 15.2 minutes respectively.

Turning and dumping time : 2 min.

The cycle time and number of trips, output per hour of and the number of dumpers per shovel hour for different loads are given below in table 6.11.4. (*i*) :

TABLE 6.11.4. (*i*).

Particulars	Lead One Way in Feet					
	1000	2000	3000	5000	6000	8000
Cycle Time in min.	4.2	6.1	8.0	11.8	13.7	17.5
Trips in 50 min. hr.	11.9	8.2	6.25	4.25	3.65	2.86
Output per hr. at 55% efficiency	14.7*	10	7.7.	5.3	4.5	3.54
Dumper per shovel hour.	2**	3	4	6	8	10

* 11.9x0.65x1.9 :14.7

** $\frac{34}{14.7}$: 2.4

11.9 = No. of trips in a 50 min. hour.
0.65 = Efficiency factor
1.9. = CFC Borrow measure of the Cap. 9/11.4 cyd. Dumpers.
34.0 =Out put of a shovel
14.7. = Out put per hour of the Dumper

A motorgrader and a water tanker is necessary to maintain the haul roads in good condition for efficient working of hauling units.

The total cost of equipment required per hour shovel output and the rate for excavating, transporting and dumping a CFC of blasted rock are given in tables 6.11.4 (*ii*) & (*iii*) respectively.

TABLE 6.11.4.(*ii*)

Equipment Cost per Hour output of shovel in blasted rock.

Lead one way haul in feet	Equipment Cost									
	2-1/2 cyd. shovel		Tractor dozer		9.7 Cyds. Rear dump		115 h.p. Motorgrader		Water tanker	Total amount
	Nos.	Amt.	Nos.	Amt.	Nos.	Amt.	Nos.	Amt.		
1	2	3	4	5	6	7	8	9	10	11
		Rs.		Rs.		Rs.		Rs.	Rs.	Rs.
1000ft.	1	70	1/3	11	2	68	1/4	6	5	160
2000ft.	1	70	1/3	11	3	102	1/4	6	5	194
3000ft.	1	70	1/3	11	4	136	1/4	6	5	228
5000ft.	1	70	1/3	11	6	204	1/4	6	5	296
6000ft.	1	70	1/3	11	8	272	1/4	6	5	364
8000ft.	1	70	1/3	11	10	340	1/4	6	5	432

TABLE 6.11.4. *(iii)*

Rate for mucking per CFC of blasted Rock by $2\frac{1}{2}$ cu. yd. shovel and hauling near dump (9.7 cyd).

Lead one way haul in feet	Equipment Cost	Output CFC	Rate per CFC
	Rs.		Rs.
1000 ft.	160	40	4.0
2000 ft.	194	40	4.85
3000 ft.	228	40	5.70
5000 ft.	296	40	7.40
6000 ft.	364	40	9.10
8000 ft.	432	40	10.08

6.11.5 Analysis of Rate for Earth-work

Output of $2\frac{1}{2}$ cyd. shovel in good common earth } 52 CFC per hour.

Bottom dump of 13/15.1 cyds. will have an average capacity of 14 cyds. The percentage of swell of common earth is 25% and the swell factor is 100 : 0.8. The borrow measure of 14 cyds. is therefore 14 x 0.8: 11.2 cyds. or 3 CFC.

Loading time in minutes: $\frac{3 \times 60}{52}$: 3.46 min.

Spotting time for loading muck } 0.50 min.

Average travel speed of bottom dump } 15 m.p.h.

For leads 2000, 3000, 5000, 6000 and 8000 feet, the hauling and returning time is 3.02, 4.53, 7.55, 9.06 and 12.08 minutes respectively.

Turning and dumping time : 1.00 min.

The cycle times, number of trips per hour, the average output and number of dumpers required to haul an hour output of shovel for different leads is tabulated below.:—

TABLE 6.11.5. (*i*)

Lead one way haul in feet	1000 ft.	2000 ft.	3000 ft.	5000 ft.	6000 ft.	8000 ft.
Total cycle time in minutes.	3.01	4.52	6.03	9.05	10.56	13.58
Trips per 50 min.-hr.	16.7	11.0	8.30	5.53	4.75	3.7
Output per hr. @ CFC 65% efficiency.	32.6	21.5	16.20	10.80	9.25	7.2
No. of dumpers per shovel hour.	1.6	2	3.0	5	6	7

Equipment charges for handling Common earth equipment to an hour of 2½ cyd. shovel are given in table 6.11. (II) below.

TABLE 6.11.5 (*ii*)

Equipment Cost per hour output of shovel

Lead one way haul in feet	2-1/2 cyds. shovel		Tractor dozer		13 cyds. bottom dumps		115 h.p. Motor grader.		Water tanker	Total amount
	Nos.	Amt.	Nos.	Amt.	Nos.	Amt.	Nos.	Amt.	Amt.	
1	2	3	4	5	6	7	8	9	10	11
		Rs.		Rs.		Rs.		Rs.	Rs.	Rs.
1000ft.	1	64	1/3	10	2	74	1/4	6	5	159
2000ft.	1	64	1/3	10	2	74	1/4	6	5	159
3000ft.	1	64	1/3	10	3	111	1/4	6	5	196
5000ft.	1	64	1/3	10	5	185	1/4	6	5	270
6000ft.	1	64	1/3	10	6	222	1/4	6	5	307
8000ft.	1	64	1/3	10	7	259	1/4	6	5	344

TABLE 6.11.5.(*iii*)

Rate per CFC of Common earth excavated and loaded by 21/2 cu. yd. shovel and hauled by 13 cu. yds. bottom dump.

Load one way haul	Equipment cost	Output CFC	Rate per CFC
1000ft.	Rs.159	52	Rs.3
2000ft.	Rs.159	52	Rs.3
3000ft.	Rs.196	52	Rs.3.75
5000ft.	Rs.270	52	Rs.5.0
6000ft.	Rs.307	52	Rs.6.0
8000ft.	Rs.344	52	Rs.6.5

6.11.6. In the case of other soils, the rates can be worked out on the same lines. Due to the different swell factor the output per hour of the dumpers will slightly vary. Its effect on the number of dumpers will require for different leads per shovel output is not very appreciable and so the equipment combination can be taken the same as in the case of common earth ; the rates will be inversely proportional to the outputs. The rates for earthwork in different soils are given below in table 6.11.6:—

TABLE 6.11.6

Earthwork rates by shovels—Rate per CFC.

Soils	Load one way haul in feet					
	1000	2000	3000	5000	6000	8000
Moist loam or light sandy clay.	2.75	2.75	3.5	4.5	5.5	6
Sand & gravel	2.75	2.75	3.5	5	5.5	6
Good common earth	3	3	3.75	5	6	6.5
Clay, hard & tough	3.5	3.5	4.5	5.75	7	7.5
Clay, wet & sticky	4.6	4.6	5.75	7.5	9	10

6.11.7. Earthwork by Tractor-drawn Scrapers

The excavation and hauling rates of 10/12.5 cyds. and 15/20 cyds. scrapers are as per tables 6.11.7. (*i*) and 6.11.7. (*ii*) and the average rates are those given in table 6.11.7. (*iii*), worked out on the basis of outputs shown in tables 6.6.10 (*ii*) (a) and (b), the hourly rate of tractor scrapers being Rs. 39 and Rs. 49 respectively.

TABLE 6.11.7.(*i*)

Unit rates of excavation and transport by tractor-drawn 10/12.5 *cyds. scrapers*

Sl.No.	Soil	Lead one way haul in feet					
		500 Rate per CFC	600 Rate per CFC	800 Rate per CFC	1000 Rate per CFC	1200 Rate per CFC	1500 Rate per CFC
1	2	3	4	5	6	7	8
1.	Light loam or crumbly soil	2.05	2.17	2.30	2.44	2.79	3.25
2.	Sand & gravel	2.05	2.17	2.30	2.44	2.79	3.25
3.	Good common earth	2.17	2.30	2.44	2.60	2.79	3.25
4.	Clay, hard & tough	2.17	2.30	2.44	2.60	3.0	3.55
5.	Murum	2.05	2.17	2.30	2.44	2.79	3.25
6.	Hard murum	2.30	2.44	2.60	2.60	3.0	3.55
7.	Clay, wet & sticky	2.30	2.44	2.60	2.60	3.0	3.55

TABLE 6.11.7.(*ii*)

Unit rates of excavation and transport by tractor-drawn 15/20 *cyds. scrapers*

1.	Light loam or crumbly soil	1.63	1.75	1.88	2.04	2.23	2.58
2.	Sand& gravel	1.58	1.69	1.81	1.96	2.23	2.58
3.	Good common earth	1.69	1.81	1.96	2.12	2.34	2.72
4.	Clay, hard & tough	1.75	1.88	2.04	2.23	2.34	2.72
5.	Murum	1.58	1.69	1.81	1.96	2.23	2.58
6.	Hard murum	1.81	1.88	2.04	2.23	2.45	2.88
7.	Clay, wet & sticky	2.06	2.16	2.32	2.42	2.73	3.22

TABLE 6.11.7.(*iii*)

Average rate per CFC of working tractor scraper

Sl. No.	Soil	Lead one way haul in feet					
		500 Rate per CFC	600 Rate per CFC	800 Rate per CFC	1000 Rate per CFC	1200 Rate per CFC	1500 Rate per CFC
1.	Light loam or crumbly silt	1.84	1.96	2.09	2.24	2.01	2.91
2.	Sand and gravel	1.84	1.93	2.06	2.20	2.01	2.92
3.	Good common earth	1.93	2.06	2.20	2.36	2.07	2.99
4.	Clay, hard & tough	1.91	2.09	2.24	2.42	2.17	3.14
5.	Murum]	1.82	1.93	2.06	2.20	2.51	2.92
6.	Hard murum	2.06	2.16	2.32	2.42	2.73	3.22
7.	Clay, wet & sticky	2.06	2.16	2.32	2.42	2.73	3.22

.6.11.8. Other Units Assisting Tractor Scraper Operation

A pusher or a rooter will be required to assist excavation when the soil is hard. A rooter is not necessary in light loam, sand and gravel, common earth, but is required in hard and tough clay, murum, hard murum and wet and sticky clay. A pusher is not required in case of light loam and good common earth.

6.11.9. The number of pushers required per scraper is equal to cycle time of pusher/cycle time of scrapers. On an average a pusher tractor is required for four scrapers. The average cost of pushing is equal to the earthwork rate in table 6.11.7. (iii) use rate of pusher divided by the number of scrapers a pusher will serve × the average use-rate of drawn scraper. This amounts to about Rs. 0.4 per CFC.

The average cost of rooting per CFC is about Rs. 0.04.

6.11.10. The following table gives the rate per C.F.C. (borrow measure) in different soils of tractor, scraper operation assisted by dozers and rooters where necessary.

TABLE 6.11.10

Rates of Earthwork by Tractor-Scrapers

Sl. No.	Soils.	Lead one way haul in feet					
		500	600	800	1000	1200	1500
1	2	3	4	5	6	7	8
1.	Light loam or crumbly silt	1.84	1.96	2.09	2.24	2.00	2.90
2.	Sand & gravel	2.24	2.33	2.46	2.60	2.41	3.32
3.	Good common earth	1.93	2.06	2.20	2.36	2.07	2.99
4.	Clay, hard & tough	2.35	2.53	2.68	2.86	2.61	3.58
5.	Murum	2.26	2.37	2.50	2.64	2.95	3.36
6.	Hard murum	2.50	2.60	2.76	2.86	3.17	3.66
7.	Clay, wet & sticky	2.50	2.60	2.76	2.86	3.17	3.66

6.11.11. Earthwork by Motor-Scrapers

Rates for excavation and hauling by scrapers of 10/13 and 15/20 cyds. in different soils are tabulated in tables 6.11.11 (*i*) and (*ii*) and their average in table 6.11.11. (*iii*) using the outputs mentioned in tables 6.6.12 (*ii*) (a) and (b) and hourly rates of Rs. 43 and Rs. 56 respectively.

TABLE 6.11.11 (*i*)

Unit rate of excavation and hauling by Motor-scraper 10/13 *cyds. capacity*

Sl. No.	Soils	Lead in one way haul in feet						
		1000	1500	2000	2500	3000	4000	5000
1	2	3	4	5	6	7	8	9
1.	Light loam or crumbly silt	1.87	2.05	2.15	2.39	2.53	2.87	3.31
2.	Sand & gravel	1.87	2.05	2.15	2.39	2.53	2.87	3.31
3.	Good common earth	1.95	2.15	2.26	2.53	2.69	3.07	3.31
4.	Clay, hard & tough	2.05	2.15	2.26	2.53	2.69	3.07	3.31
5.	Murum	1.87	2.05	2.15	2.39	2.53	2.87	3.31
6.	Hard murum	2.05	2.26	2.39	2.69	2.69	3.07	3.58
7.	Clay, wet & sticky	2.06	2.26	2.39	2.69	2.69	3.07	3.58

TABLE 6.11.11 (*ii*)

Unit rate of excavation and hauling by Motor-Scraper 15/20 *cyds. capacity*

Sl. No.	Soils	Lead in one way haul in feet						
		1000	1500	2000	2500	3000	4000	5000
1	2	3	4	5	6	7	8	9
1.	Light loam or crumbly silt	1.56	1.71	1.87	2.07	2.15	2.44	2.80
2.	Sand & gravel	1.51	1.65	1.81	2.00	2.07	2.44	2.80
3.	Common earth	1.60	1.75	1.93	2.15	2.24	2.54	2.94
4.	Clay, hard & tough	1.65	1.81	2.00	2.24	2.33	2.66	2.30
5.	Murum	1.51	1.65	1.81	2.00	2.07	2.44	2.80
6.	Hard murum	1.71	1.87	2.07	2.24	2.33	2.66	3.11
7.	Clay, wet & sticky	1.71	1.87	2.07	2.24	2.33	2.66	3.11

TABLE 6.11.11.(*iii*)

Average rate per CFC of using Motor-Scraper

1.	Light loam or crumbly silt	1.72	1.88	2.01	2.23	2.34	2.66	3.06
2.	Sand & gravel	1.60	1.86	1.98	2.20	2.30	2.66	3.06
3.	Common earth	1.73	1.96	2.10	2.34	2.47	2.81	3.13
4.	Clay, hard & tough	1.85	1.98	2.13	2.39	2.51	2.87	3.44
5.	Murum	1.69	1.86	1.98	2.20	2.30	2.66	3.06
6.	Hard Murum	1.83	2,07	2.23	2.47	2.51	2.87	3.35
7.	Clay, wet & sticky	1.83	2.07	2.23	2.47	2.51	2.87	3.35

6.11.12. On an average one pusher tractor is required to assist three scrapers; the share of pusher is about Rs. 0.5 per C.F.C. of earth moved. The cost of rooting, where necessary, is about Rs. 0.04 per C.F.C.

The rates per C.F.C. (Borrow measure) for Motor scraper operation in different soils assisted by dozers and rooters where necessary are given below :—

TABLE 6.11.12.

Rates for excavation and hauling by Motorised Scraper

Sl. No.	Soils	Lead one way haul in feet						
		1000	1500	2000	2500	3000	4000	5000
1	2	3	4	5	6	7	8	9
1.	Light loam or crumbly silt	1.72	1.86	2.01	2.23	2.34	2.66	3.06
2.	Sand and gravel	2.19	2.35	2.48	2.70	2.80	3.16	3.56
3.	Good common earth	1.78	1.95	2.10	2.34	2.47	2.81	3.13
4.	Clay, hard & tough	2.39	2.52	2.57	2.93	3.05	3.41	3.93
5.	Murum	2.23	2.39	2.52	2.74	2.84	3.20	3.60
6.	Hard murum	2.42	2.61	2.77	3.01	3.05	3.41	3.89
7.	Clay, wet & sticky	2.42	2.61	2.77	3.01	3.05	3.41	3.89

6.12. Consolidation of Loose Earth

6.12.1. Rate for Trimming, Watering and Compaction

The equipment used for trimming, watering and compaction of an earthen bank are tractor-dozers, water sprinkler trucks and rollers or tractor-drawn sheepsfoot rollers. A motor grader is sometimes used in addition to the dozer. In some cases watering is done by manual labour and the quantity of water depends on the job specifications and soil condition. On some projects where heavy scrapers dump the earth on bank, no rollers are used, as the compaction is supposed to be achieved by the weight of the scrapers and other hauling equipment on the bank.

6.12.2. About half-an hour of dozing is necessary for an hourly output of a shovel and the cost of watering is about Rs. 0.25 per C.F.C.

6.12.3. Analysis of Rate of Consolidation

(a) Cost per C.F.C. dozing @ Rs. 38 per hour. } Rs. 0.38

(b) Cost of Water per C.F.C.	Rs. 0.25
(c) Cost of Rolling Output of twin drum sheepsfoot roller for 3″ depth layer and 10 passes.	72 C.F.C. per hr.
Use Rate per Hour of D. 4 tractor drum roller	Rs. 15.1
Cost per C.F.C. of rolling	Rs. 0.21

Abstract

Cost per CFC (borrow)

(a)	Dozing	Rs. 0.38
(b)	Watering	Rs. 0.25
(c)	Compaction	Rs. 0.21
	TOTAL	Rs. 0.84

6.13. HYDRAULIC SLUICING

6.13.1. This Chapter will not be complete without a mention of one of the novel methods of moving earth other than those mentioned above. It is hydraulic sluicing.

6.13.2. It is a simple and effective way of moving earth by a stream of water at high pressure through portable nozzles called 'Hydraulic Giants' or 'Monitors' directed at the material. This method is very economic in such situations, as for example a hillside, not connected by haul roads by which earthmoving machines can reach the site.

6.13.3. This method is being effectively employed on the Bhakra Project, where 1,62,400 cu. yds. was moved in 255 hours at a cost of Rs. -/7/6 per cu. yd. inclusive of erection, depreciation and operation charges.

EARTHWORK BY HUMAN LABOUR

7.1. Earthwork and Classification of Soil

7.1.1. Earthwork by manual labour is generally confined to a maximum lead of 300 feet except in places where the quantity of work involved is too small to justify the use of the machines.

7.1.2. The classification of soils in an ascending order of effort is given below (table 7.1.2.).

TABLE 7.1.2.

Sl. No.	Type of Soil		Wt. per cft. in Borrow (lbs.)	Digging tools used in excavation	Local names
1	2		3	4	5
			Soil Characteristics		
1.		Silt & sand	90-105	Hand Shovel	Sand, silt, sandy gravel.
2.	Ordinary soil	Top soil	75-100	Hand shovel or spade	Soil, Silt.
3.		Common earth	90-110	Spade	Average loam.
4.		Clay, light	100-115	Flat pick	Clayey and Loamy sub-soil.
5		Clay, heavy or hard soil	100-125	Pointed pick	Stiff clay soft murum clay and boulder.
			Rock Characteristics		
6.		Soft rock	130-150	Crowbar or wedges	Compact gravel, hard murum, Shale, Schist soft laterite & disintegrated rock.
7.		Hard rock	150-190	Blasting	Stone, massive hard rock, abrasive massive rock.

7.2. Schedule of Manual Output and Rates

7.2.1. Excavation can be (i) *the Surface Digging* in which case the depth of cutting is not more than 12", or (ii) the *Rough* from borrows, *i.e.* cutting hillside or removal of spoil, (iii) *Deep Digging* exceeding 12" depth and (iv) *Trenching in narrow.* Rates vary according to the nature of the work involved, but we shall confine our attention here to category (i) which is the most common.

7.2.2. The Table 7.2.2. gives the effort in man-days per CFC of digging and raising spoil from excavation including rough dressing in borrows. The range of excavation rates for various soils is given in col. 4 assuming an average wage rate for unskilled male *mazdoor* and *pro rata* share of the mate at Rs. 1.8 per day.

TABLE 7.2.2.

Digging not exceeding 3' depth and raising of spoils and filling in head-load baskets or barrows.

Sl. No.	Type of soil	Range of labour effort per CFC (man-days)	Range of rates per CFC (Rs.)
1	2	3	4
1.	Sand and silt	0.25—0.4	0.45—0.72
2.	Top soil	0.4—0.6	0.72—1.08
3.	Common earth	0.5—0.8	0.9—1.44
4.	Clay, light	0.7—1.0	1.26—1.8
5.	Clay, heavy	0.85—1.2	1.5—2.2
6.	Soft rock	1.4—2.5	2.5—4.5

NOTE:—These labours and rates do not include transporting.

7.3. Removal of Spoil

7.3.1. Table 7.3.1. gives the effort needed and rate fixed per CFC of excavated materials by female labour @ Rs. 1.3 per diem for different leads.

TABLE 7.3.1.

Labour effort constants in man-days and rates in rupees for removal of spoil per C.F.C.

Sl. No.	Horizontal distance between (CFR unit)	Removal of Soil: Soil — Labour	Soil — Rate	Rock — Labour	Rock — Rate	Remarks
1	2	3	4	5	6	7
1.	.25	.13	.17	.17	.22	It is assumed that a person carrying soil can travel 200 ft. per minute and it takes .06 minute to unload a basket. For carrying rock the speed will be reduced to 150 ft./min.
2.	.50	.23	.30	.30	.39	
3.	1.0	.43	.58	.59	.77	
4.	1.5	.63	.82	.86	1.12	
5.	2.0	.83	1.08	1.14	1.48	
6.	2.5	1.03	1.34	1.43	1.86	

7.3.2. In case when the spoil has to be loaded into baskets from an existing heap and consolidated bank measured, the extra labour to be added would be 0.2 and 0.3 to columns 3 and 5 while 0.26 and 0.39 are to be added to the rates.

7.3.3. Table 7.3.3. gives rates (per CFC) of excavation in muck and over areas for leads between 50′—60′ and digging not exceeding 3′ depth.

TABLE 7.3.3.

Manual Operations

Sl. No.	Type of soil	Range of labour effort (Man-days)	Rates at average wages at Rs. 1.5	1.8	2.1
1	2	3	4	5	6
1.	Sand & silt	0.48-0.63	0.72-0.94	0.86-1.13	1.01-1.32
2.	Top soil	0.63-0.83	0.94-1.25	1.13-1.49	1.32-1.74
3.	Common earth	0.73-1.03	1.09-1.54	1.31-1.85	1.53-2.10
4.	Clay, light	0.93-1.36	1.4-2.04	1.63-2.45	1.95-2.85
5.	Clay, heavy	1.06-1.53	1.62-2.29	1.95-2.76	2.27-3.21
6.	Soft rock	1.70-2.8	2.55-4.20	3.06-5.04	3.57-5.88

7.3.4. Combining the two tables 7.2.2. and 7.3.1. we have the two tables 7.3.4. (*i*) and 7.3.4. (*ii*) giving fair labour constants and rates for excavation with various leads.

TABLE 7.3.4. (*i*)

Rates of Earthwork by Manual Labour

Sl. No.	Type of soil	Labour effort in man-days for digging and disposal of spoil for leads					
		0.25 CFR	0.5 CFR	1.0 CFR	1.5 CFR	2.0 CFR	2.5 CFR
1	2	3	4	5	6	7	8
1.	Sand and silt	0.38-0.53	0.48-0.63	0.68-0.83	0.88-1.03	1.08-1.23	1.28-1.43
2.	Top soil	0.53-0.73	0.63-0.83	0.83-1.03	1.03-1.23	1.23-1.43	1.43-1.63
3.	Common earth	0.63-0.93	0.73-1.03	0.93-1.23	1.13-1.43	1.33-1.63	1.53-1.83
4.	Clay, light	0.93-1.33	1.03-1.53	1.23-1.63	1.43-1.83	1.63-2.03	1.83-2.23
5.	Clay, heavy	1.13-1.63	1.23-1.73	1.43-1.93	163-2.13.	1.83-2.33	2.03-2.53
6.	Soft rock	1.57-2.67	1.70-2.80	1.90-3.09	2.26-3.36	2.54-3.64	2.83-3.93

TABLE 7.3.4. (*ii*)

Rates for Earthwork by Manual Labour

Sl. No.	Type of soil	Rates of excavation for distances (CFR) from the excavation point					
		0.25	0.5	1.0	1.5	2.0	2.5
1	2	3	4	5	6	7	8
1.	Sand and silt	0.62-.89	0.75-1.0	1.03-1.23	1·27-1.47	1.53-1.75	1.79-2.00
2.	Top soil	0.89-1.25	1.0-1.4	1.23-1.68	1.47-1.90	1.73-2.16	2.00-2.42
3.	Common earth	1.07-1.57	1.2-1.7	1.48-1.98	1.72-2.22	1.98-2.54	2.24-2.74
4.	Clay, light	1.43-1.87	1.56-2.1	1.84-2.38	2.08-2.62	2.34-2.88	2.60-3.14
5.	Clay, heavy	1.67-2.37	1.8-2.8	2.08-2.78	2.32-3.02	2.58-2.58	2.84-3.54
6.	Soft rock	2.72-4.72	2.89-4.89	3.27-5.27	3.62-5.62	3.98-5.98	4.36-6.36

7.3.5. Average rates for excavation in different soils for a lead between 500/60′ and 3′ depth would be as under (Table 7.3.5.). The rates are primary.

TABLE 7.3.5.

Sl. No.	Type of soil	Average rates digging 3′ depth and lead 50′-60′ Rs. per C.F.C.	Remarks
1	2	3	4
1.	Sand and silt	0.87	For every extra lead of 50′ add Rs. 0.25
2.	Top soil	1.20	
3.	Common earth	1.45	
4.	Clay, light	1.83	
5.	Clay, heavy	2.30	

7.4. Excavation Rates and Output (Manual) from Projects

7.4.1. The excavation rates have been tabulated below for different types of soils for ·50 to ·60 CFR lead and digging not exceeding 3′. Rates have been obtained from applicable sanctioned schedule of rates or from observed recorded data.

7.4.2. Sanctioned rates of digging and disposal of spoil up to 60′ lead and depth of excavation not exceeding 3′ in various soils have been tabulated for a few projects.

TABLE 7.4.2. (*i*)

Excavation by Manual Labour
(*Type of Soil: Silt and Sand*)

Sl. No.	Name of Project	Rate Rs. per CFC	Man-days per CFC	Weighted average wage rate	Remarks
1	2	3	4	5	6
1.	Nangai	1.22	0.57	2.3	Rate as per table 7.3.4. (*ii*) =Rs. 0.75 to 1.00
2.	Gangapur	0.86	0.53	1.3	
3.	Lower Bhawani	0.73	0.58	1.25	
4.	Malampuzha	0.80	0.66	1.21	
5.	Peechi	0.98	0.67	1.46	

TABLE 7.4.2. (*ii*)

Excavation by Manual Labour
(*Type of Soil* :—*Common Earth*)

Sl. No.	Name of Project	Rate Rs. per CFC.	Weighted average wage rate.	Man-days per CFC		Remarks
1	2	3	4	5		6
1.	Nangal.	1.49	0.70	2.125	Lead	Rates as per table 7.3.4. (*ii*) =Rs. 1.20-1.7
2.	Sarda Sagar	2.00	1.14	1.75	100′ Lead 5′ Lift	Converted to 60′ lead and 3′ lift
		1.56	0.89			
3.	Matatila	1.6	1.097	1.46	109′ Lead 5′ Lift	-do-
		1.2	0.82			
4.	Chambal (Raj.) (Kotah)	2.0	1.37	1.46		
		1.7	1.16			
5.	Gangapur	1.22	0.73	1.625	60′ Lead 3′ Lift	
6.	Lower Bhawani	1.00	0.80	1.25	”	
7.	Malampuzha	1.09	0.90	1.21	”	
8.	Peechi	1.20	0.83	1.46	”	

TABLE 7.4.2. (*iii*)

Excavation by Manual Labour
(*Type of Soil* : *Clay Light.*)

Sl. No.	Name of Project	Rate Rs. per CFC	Man days per CFC	Weighted average wage rate		Remarks
1	2	3	4	5		6
1.	Chambal	2.30	1.57	1.46	60′ Lead 3′ Lift	Rates as per table 7.4.2. (*ii*) =Rs. 1.56-2.1
	(Kotah)	2.00	1.37	—	100 ft. Lead 5 ft. Lift	Coverted to 60′ lead and 3′ lift
2.	Hirakud	2.03	1.39	1.46	60′ Lead 5′ Lift	
		1.81	1.24	—		
3.	Tungabhadra (Hyd.)	1.93	1.57	1.23	60 ft. Lead 3 ft. Lift	
		1.85	1.5	—	50 ft. Lead 5 ft. Lift	-do-
4.	Peechi	1.54	1.05	1.46	60′ Lead 5′ Lift	
5.	Lower Bhawani	1.27	1.02	1.25	-do-	

TABLE 7.4.2. (*iv*)
Excavation by Manual Labour
(*Type of Soil: Clay Heavy*)

Sl. No.	Name of Project	Rate Rs. per CFC	Man-days per CFC	Weighted average wage rate		Remarks
1	2	3	4	5		6
1.	Matatila	2.3	1.57	1.46	Lead	Rates as per table 7.4.3. (*ii*) =Rs. 1.8 to 2.8
		1.9	1.30		100 ft. lead 5 ft. Lift	Converted to 60' lead & 3' Lift.
2.	Chambal (Raj) Kotah	2.8	1.92	1.46		
		2.5	1.71		100 ft. Lead 5 ft. Lift	
3.	Hirakud	2.5	1.71	1.46		
		2.28	1.56		100 ft. Lead 5 ft. Lift	-do-
4.	Tungabhadra (And.)	2.12	1.93	1.10		
5.	Tungabhadra (Hyd.)	2.19	1.78	1.23		
		2.11	1.71	—	50 ft. Lead 5 ft. Lift	-do-
6.	Malampuzha	1.89	1.56	1.21	60 ft. Lead 3 ft. Lift	

TABLE 7.4.2. (*v*)
Excavation by Manual Labour
(*Type of Soil: Hard Gravelly Soil*)

Sl. No.	Name of Project	Rate Rs. per CFC	Man-days per CFC	Weighted average wage rate		Remarks
1	2	3	4	5		6
1.	Nangal	3.14	1.48	2.125	Lead	
2.	Sarda Hydel	3.00	1.71	1.75		
		2.56	1.46		100 ft. lead 5 ft. Lift	Converted to 60 lead and 3 lift.
3.	Matatila	3.00	2.06	1.46		
		2.6	1.78		100 ft. Lead 5 ft. Lift	-do-
4.	Hirakud	3.00	2.05	1.46		
		2.78	1.90		100 ft. Lead 5 ft. Lift	
5.	Tungabhadra (Andhra)	2.60	2.36	1.10	60 ft. Lead 5 ft. Lift	
6.	Tungabhadra (Hyd.)	2.25	1.83	1.23		
		2.17	1.76		50 ft. Lead 5 ft. Lift	-do-
7.	Malampuzha	2.14	1.77	1.21	60 ft. Lead 3 ft. Lift	
8.	Peechi	2.18	1.49	1.46		

TABLE 7.4.2. (*vi*)

Excavation by Manual Labour

(*Type of Soil—Soft Rock*)

Sl. No.	Name of Project	Rate Rs. per CFC	Man-days per CFC	Weighted average wage rate	Remarks
1	2	3	4	5	6
1.	Chambal (Raj.) Kotah	2.93	2.00	1.46	
		2.43	1.67		100 ft. Lead 5 ft. Lift Converted to 60' lead and 3' Lift
2.	Mayurakshi	4.00	2.04	1.96	
		3.40	1.74		100 ft. Lead 5 ft. Lift. -do-
3.	Hirakud	4.5	3.08	1.46	
		4.28	2.93		100 ft. Lead 5 ft. Lift. -do-
4.	Gangapur	3.36	2.07	1.625	
5.	Tungabhadra (Andhra)	3.00	2.73	1.10	
6.	Tungabhadra (Hyd.)	3.32	2.70	1.23	
		3.24	2.63		50 ft. Lead 5 ft. Lift -do-
7.	Lower Bhawani	2.44	1.95	1.25	
8.	Malampuzha	2.89	2.39	1.21	
9.	Peechi	3.68	2.52	1.46	

7.5. Hand Shovelling

7.5.1. The cost of hand shovelling depends upon the kind of material, lift, kind of shovel, and the skill and inclination of the workmen. All materials that can be shovelled either while loading or unloading should be measured and rated in CFC units for these functions. The range of output and average rates are given in table 7.5.1. Rates for carriage should, however, be paid per ton on large works where arrangements for weighing trucks ought to be made.

TABLE 7.5.1.

Shovelling of Materials (loading & unloading)

(Daily Weighted wage rate = *Rs.* 2.0)

Kind of Material	Unloading rates— Truck to ground or stack to stack			Loading rates—Ground to truck or wagon	
	Output per man Range	Output per shift Average (CFC)	Rates per CFC	Rates for lifts up to 4′ per CFC	Rates for lifts 4′—6′ per CFC
1	2	3	4	5	6
Cinders	4-6	5	0.4	0.5	0.6
Sand or Surkhi	3-5	4	0.5	0.6	0.7
Soil heaps	3-4	3.5	0.6	0.7	0.8
Gravel	2.5-3.5	3	0.7	0.8	0.9
Crushed stone in stacks	2-3	2.5	0.8	0.9	1.0

7.5.2. *Illustrative example* :—Determine cost for unloading bank-rum gravel from Railway wagon to platform.

Volume of gravel in CFC units	=	5
Rate per CFC for unloading (Col. 4)	=	Rs. 0.7
Rate for unloading gravel per wagon	=	Rs. 3.5

7.6. TRANSPORT BY DONKEYS OR MULES

7.6.1. Donkeys or mules are often employed in transporting materials particularly in hauling dirt. Average rate of travel for these animals working over a shift of eight hours may be reckoned as 3 miles (16,000′) an hour approximately. Load carried is usually one cu. ft. and the

hire charge inclusive of the attendant labour is Rs. 2/8 per day—6 animals usually requiring one donkeyman and two assistant boys. The rate of haulage can now be derived for varying leads (Table 7.6.1).

Loading and unloading time—2·0 minutes.

TABLE 7.6.1.

Lead	Time taken per trip			No. of trips per day	Rate per CFC (Rs.)
	Haulage (min.)	Loading and unloading (min.)	Total (min.)		
200	1.50	2.0	3.5	137	1.8
300	2.25	2.0	4.25	113	2.1
400	3.0	2.0	5.0	96	2.6
500	3.75	2.0	5.75	84	3.0
600	4.5	2.0	6.50	74	3.4
700	5.25	2.0	7.25	66	3.8
800	6.0	2.0	8.0	60	4.2
900	6.75	2.0	8.75	55	4.6
1000	7.50	2.0	9.50	50	5.0
1500	10.25	2.0	12.25	39	6.4
2000	15.00	2.0	17.0	28	8.9
2500	18.75	2.0	20.75	23	10.8

7.7. Clearing Jungle

7.7.1. Rates for light and thick jungle clearance with and without rooting out by manual labour are given in table 7.7.1.

TABLE 7.7.1.

Analysis and Schedule of Rates for clearing site by Manual Labour

Item	Unit	No. of Labour	Rate (Rs.)	Per	Amount (Rs.)	Rate per Acre (Rs.)
Clearing scrub jungle without rooting out.	MFS	1	1.8	each	1.8	78
Clearing scrub jungle including rooting out.	,,	2	1.8	each	3.3	157
Clearing light jungle without rooting out.	,,	2	1.8	each	3.6	157
Clearing light jungle including rooting out.	,,	4	1.8	each	7.2	314
Clearing heavy jungle without rooting out.	,,	4	1.8	each	7.2	324
Clearing heavy jungle including rooting out.	,,	8	1.8	each	14.4	627
Clearing thickly wooded and thorny jungle including rooting out.	,,	9	1.8	each	16.2	706

TRANSPORT

8.1. Transporting Materials of Construction

8.1.1. Transportation figures practically occur in all items of construction and very often these account for a large portion of the total cost. Some of the important means of transport which are in use on the projects are bullock carts, petrol and diesel trucks, tip wagons on trolley line pushed by hand or pulled by a steam or a diesel locomotive, dumpers, belt conveyors and ropeways. Transports by men or by donkeys have been discussed in the preceding chapter.

8.1.2. In transporting materials the operations involved are loading, carriage, and unloading at the delivery point. Stacking is excluded from the present study.

8.2. Weights of Principal Construction Materials

8.2.1. The weights of principal construction materials are given in the engineering data books but weights for some local materials are recorded here (table 8.2.1.) and these would be utilised in our studies for transporting them.

TABLE 8.2.1.

Weights of Local Structural Materials

Sl. No.	Nature of materials	Weights		Remarks
		Lbs. per CFC	Tons per CFC.	
1	2	3	4	5
1.	Quarried and crushed stone			
	i. Lime stone	80	3.57	The data given is based on 45% voids.
	ii. Granite.	92	4.11	
	iii. Basalt	95	4.24	
2.	Bank-rum shingle containing sand.	100	4.46	
3.	Gravel or shingle without sand.	94	4.20	
4.	Clean pit sand, dry.	90	4.02	
5.	Slaked Lime powder.	60	2.68	
6.	Unslaked Lime.	30	1.34	
7.	Surkhi ground, dry and loose.	72	3.21	
8.	Timber.			
	i. Deodar	36	1.6	
	ii. Teak	45	2.0	
	iii. Sal	47	2.1	

TABLE 8.2.1.—Contd.

Bricks

Sl. No.	Size of Bricks	Weight per 1000 Nos. (ton)	No. of bricks per ton	Remarks
1	2	3	4	5
9.	$9'' \times 4\frac{3}{8}'' \times 2\frac{3}{8}''$	3.21	313	
10.	$9'' \times 4\frac{1}{2}'' \times 1\frac{1}{4}''$	1.57	637	
11.	$12'' \times 6'' \times 2''$	4.46	224	
12.	$10'' \times 5'' \times 2\frac{1}{2}''$	3.88	258	
13.	$10'' \times 4\frac{7}{8}'' \times 2\frac{3}{4}''$	4.16	240	

8.3. Cost of Carriage by Carts

8.3.1. There are many types of carts in the country varying in their capacity and their rates of hire vary from Rs. 2/8/- to Rs. 6/10/- including labour charges of the driver, average being Rs. 5/-/-. Table 8.3.1. gives the rates prevalent in various localities.

TABLE 8.3.1.

Hire Rates of Carts per day (with attendant and a pair of bullocks.)

Station 1	State 2	Daily hire rate 3
Gangapur	Bombay	4/8/- to 6/-/-
Tungabhadra	Madras	5/8/-
Chambal	Madhya Bharat	7/-/-
Hirakud	Orissa	4/8/-
Bhakra-Nangal	Punjab	6/-/-
Konar	D.V.C.	6/10/-
Rihand	U.P.	4/8/- to 5/8/-
Madhya Bharat	Madhya Bharat	3/8/- to 4/8/-
Ahmed Nagar Divn.	Bombay	4/8/-
Ghataprabha Divn.	Bombay	5/-/- to 6/-/-
Trinulvali Divn.	Madras	5/-/-
Jabalpur Circle.	Madhya Pradesh	2/8/- to 4/-/-
Berar and Nagpur Circle.	Madhya Pradesh	3/-/- to 5/-/-

8.3.2. Table 8.3.2. is extracted from C.P.W.D., schedule (1950 publication) for carriage by *Thelas*. These *Thelas* are big 4-wheeled carts pulled by a strong pair of bullocks and carry considerably more load than the usual bullock carts. The hire rate is Rs. 12/-/- per day.

TABLE 8.3.2.

Handling and Transporting Materials (carriage by carts)

Lead in Miles	Number of trips per 8 hours	Cost per trip	Remarks
1	2	3	4
½	6.96	1/11/7	
1	5.16	2/5/3	
1½	4.10	2/14/10	1. Number of trips N = trips per 8 hours
2	3.40	3/8/6	$N = \frac{8}{\frac{2L}{S} + 4}$
2½	2.91	4/2/-	
3	2.54	4/11/7	where L = Lead in miles, S = Speed in miles per hour and ¾ hours is allowed for loading and unloading.
3½	2.25	5/5/4	
4	2.03	5/14/7	2. Speed assumed 2½ miles per hour.
4½	1.84	6/8/4	3. Bullock cart charge @Rs. 12 per 8-hour day.
5	1.68	7/2/3	
5½	1.55	7/11/10	
6	1.44	8/5/4	

8.3.3. Based on the capacity of these *Theias* and the above table the derived rates are given over various leads (table 8.3.3.). The carriage rates are primary and the units of measure differ with nature of materials. Rates can be worked out similarly for smaller sizes of carts and their hire rates.

TABLE 8.3.3.

Sl. No.	Lead in Miles	Cost per trip	Materials: Sand, lime murum, gravel, earth, ballast and building rubbish	Bricks	Cement, Steel, C.I.Pipes and other heavy materials	Timber	Tar, Bitumen	Coal
	Capacity per trip		33⅓ F.C.	500 Nos.	1.5 Ton	50 FC	1½ Ton	Ton
	Unit of Rate		C.F.C.	1000 Nos.	Ton	CFC	Ton	Ton
1	2	3	4	5	6	7	8	9
1.	½	1/11/7	5/3/-	3/7	1/2	3/7	1/2	1/12
2.	1	2/5/3	7/-	4/11	1/9	4/11	1/9	2/5
3.	1½	2/14/10	8/13	5/14	1/15	5/14	1/15	2/15
4.	2	3/8/6	10/10	7/1	2/6	7/1	2/6	3/9
5.	2½	4/2	12/6	8/4	2/12	8/4	2/12	4/2
6.	3	4/14/7	14/3	9/7	3/2	9/7	3/2	4/12
7.	Above 3 miles per ½ mile.	-/9/8	1/13	1/3	-/6/-	1/3	-/6/-	-/10/-

8.3.4. Transport by hand-pushed trolley on rails is often made use of on large projects. The rate for hauling 100 cubic feet of soil usually comes to Rs. 1/8/- per mile exclusive of the cost of tools and plant.

8.4. Transporting Materials by Motor Trucks

8.4.1. Reference was made to States to supply approved freight rates by motor trucks both per ton and per truck per mile. The data

collected is tabulated in table. 8.4.1. Rates differ with type of roads which are classed as under :—

Type A roads	=	Cemented, tarred, asphalted or metalled.
Type B roads	=	Gravel or *Kankar* roads.
Type C roads	=	Fair weather tracks.

TABLE 8.4.1.

Handling and Transporting materials over long Distances. (5 *Ton lorries*—155″ *Base*)

Sl. No.	Source of data	Class of roads	Freight per ton per mile.	Freight rate per truck per mile including operation labour/5 tons.
1	2	3	4	5
1.	Transport Commissioner, U.P.	A B	0-4-8 0-7-9	1/1/6 (loaded) -/12/6 (empty) (b) 1/4/-
2.	State Motor Transport Controller, Delhi.	A	0-9-4	1/4/-
3.	Transport Commissioner, Rajasthan, Jaipur.	A B C	0-7-0 0-8-2 0-11-8	— — —
4.	G.M. Bombay State Road Transport Corporation.	A	0-8-0	-/11/90 (3% more on rough road.)
5.	Secretary, Transport Deptt., East Punjab.	A B	0-7-0 0-9-4	1/4/- 1/6/-
6.	State Transport Commissioner, Bihar.	A B	0-4-8 0-6-0	-/12/- -/12/-
7.	Secretary, State Transport Authority, Bombay.		0-8-0	(b) 1/-/-
8.	Secretary, State Transport Authority, Madhya Pradesh.	A	0-14-0 (Ceiling)	1/-/-
9.	Director, Transport Department, Travancore-Cochin.	A C	0-6-6 (Ghat Section)	1/8/- 2/-/-

NOTE :—The rates are for long distances and do not include any charge for empty journey but include loading and unloading.

B.4.2. Cost of Transport by Petrol Trucks (5-Ton)

Variables per mile :

(*a*) Cost of truck exclusive of tyres and tubes.	Rs. 17,500	
Repair charges @ 60% over life-time.	Rs. 10,500	
	Rs. 28,000	
Life of Truck : 10,000 hours. Assuming average speed over life-time of 15 m.p.h.		
Life in miles : 1,50,000		
∴ Depreciation and repairs per mile	Rs. 0.187	(a)
(*b*) Cost of six tyres and tubes @ Rs. 325/- for each set.	Rs. 1950	
Repairs and casualties @ 20%	Rs. 390	
Total	Rs. 2340	
Life of tyres and tubes assumed to be 15,000 miles.		
∴ Cost of tyres and tubes per mile.	Rs. 0.156	(b)
Total ownership cost	Rs. 0.343	
(*c*) Cost of operation materials per mile		
(i) Petrol with consumption of 8 miles per gallon on the average and cost Rs. 2.8 per gallon.	Rs. 0·350	
(ii) Mobi oil with consumption of one gallon for every 400 miles on the average and cost Rs. 5/8 per gal.	Rs. 0·015	
ii) Other oils and stores say equal to (b)	Rs. ·0·015	
Total cost of operation materials per mile	Rs. 0·380	(c)

Total a+b+c = 0·723 per mile.

Constants per day of 8 hours :

(*d*) Cost of staff per day of 8 working hours including allowance for idle days.	
Driver @ Rs. 4/8/- per day	Rs. 4·5
Cleaner @ Rs. 2/-/- per day	Rs. 2·0
Sub-total	Rs. 6·5
Add 25 % for idle days	Rs. 1·51
Total	Rs. 8·01
(*e*) Cost of labour per day of 8 working hours for loading and unloading.	
6 male mazdoors Rs. 1·75	Rs. 10·50

(*f*) Taxes and Insurance etc. per year

(i) Road Tax (varying for each State)	Rs. 300
(ii) Insurance	Rs. 250
(iii) Driver's licence fee	Rs. 10
Total	Rs. 560
Assuming 250 working days in a year, Cost per day	Rs. 2·24
Total d+e+f	=Rs. 20·75

8.4.3. Based on the above data cost of transport of materials for various leads is given in Table 8.4.3.

TABLE 8.4.3.

Cost of Transport by Petrol Trucks (5-Ton)

Lead in Miles	Cost of variables (a+b+c = Rs. 0.723 per mile) per round trip	Cost of constants (d+e+f = Rs. 20.75) per day of 8 hours	Number of trips per day	Cost of constants= Rs. 20.75 per trip (col. $\frac{3}{4}$)	Total cost per mile round trip (col. 2+5)	Capacity per trip	Primary rate per CFC Rs.
1	2	3	4	5	6	7	8
			Rubble Stone				
1.	1·446	20.75	8	2.594	4.040	CFC	4.0
2.	2·892	20.75	8	2.594	5.486	CFC	5.5
3.	4·338	20.75	7	2.964	7.302	CFC	7.3
			Bricks				Primary rate per 1000 Nos.
1.	1.446	20.75	8	2.594	4.040	1250 No.	3.02
2.	2.892	20.75	8	2.594	5.486	1250 No.	4.4
3.	4.338	20.75	7	2.964	7.302	1250 No.	5.8
			Fine and Coarse Aggregates				Primary rate per CFC
1	1.446	20.75	7	2.964	4.410	CFC	4.4
2	2.892	20.75	7	2.964	5.856	CFC	5.9
3	4.338	20.75	6	3.458	7.796	CFC	7.8

NOTES :—1. Rates include cost of labour for loading & unloading.
2. Rates are applicable to type 'A' roads—cemented, oil bound and good metalled roads.
3. Add to the above 15, 20, 30% for Class B, C & D type roads respectively.

TYPE:— B. Gravel, kankar and murum roads.
C. Rough metal roads.
D. Soft roads.

8.4.4. Cost of Transport by Diesel Trucks (5-Ton)

Analysis of rates for transport by 5 Ton Diesel Truck is given below :—

Variables per mile

(*a*)	Cost of truck exclusive of tyres and tubes.	Rs.	23,000
	Repair charges @ 60% over life-time	Rs.	13,800
	Total	Rs.	36,800
	Life = 12,000 hours.		
	Assuming average speed over life-time of 15 m.p.h.		
	Life in miles = 1,80,000		
	∴ Depreciation per mile	Rs.	0·204 (a)
(*b*)	Cost of six tyres and tubes @ Rs. 325/- per set.	Rs.	1,950
	Repairs and casualties @ 20%	Rs.	390
	Total	Rs.	2,340
	Life of tyres and tubes assumed to be 15,000 miles.		
	∴ Cost per mile	Rs.	0·156 (b)
	Total ownership cost per mile	Rs.	0·36
(*c*)	Cost of operation materials per mile		
	(i) Diesel with consumption of 10 miles per gallon on the average and cost Rs. 1/8/- per gallon.	Rs.	0·150
	(ii) Mobil oil with consumption of one gallon per every 300 miles on the average and cost Rs. 5/8 per gallon.	Rs.	0·019

(iii) Other oils and stores say equal to (b) per mile.	Rs. 0·019
Total cost of operation materials per mile	Rs. 0·188 (c)

Total a + b + c = 0·548 per mile.

Constants per day of 8 hours

(*d*) Cost of staff per day of 8 working hours including allowance for idle days

Driver @ Rs. 4/8/- per day.	Rs. 4.5
Cleaner @ Rs. 2/- per day.	Rs. 2.0
Sub-total	Rs. 6.5
Add 25% for idle days	Rs. 1.51
Total	Rs. 8.01 (d)

(*e*) Cost of labour per day of 8 working hours for loading & unloading.

6 male mazdoors @ Rs. 1.75	Rs. 10.50 (e)

(*f*) Taxes and Insurance etc. per year.

(i) Road Tax	Rs. 300*
(ii) Insurance	Rs. 250
(iii) Driver's licence fee	Rs. 10
Total	Rs. 560
Assuming 250 working days in a year, Cost per day	Rs. 2.24 (f)

Total d + e + f = Rs. 20.75

*This figure varies from State to State.

8.4.5. Based on the above data costs per unit of materials is given in Table 8.4.5.

TABLE 8.4.5.

Cost of Transport by Diesel Trucks (5-*Ton*)

Lead in miles	Cost of variables (a+b+c = Rs. 0.54 per mile) per round trip	Cost of constants (d+e+f =Rs. 20.75) per day of 8 hours	Number of trips per day	Cost of constants Rs. 20.75 per trip (col. 3/4.)	Total Cost per mile per round trip (col. 2+5)	Capacity per trip	Primary rate per CFC Rs.
1	2	3	4	5	6	7	8
			Rubble Stone				
1.	1.096	20.75	8	2.594	3.690	CFC	3.7
2.	2.192	20.75	8	2.594	4.786	CFC	4.8
3.	3.288	20.75	7	2.964	6.252	CFC	6.3
			Bricks				Primary rate per 1000 Nos.
1.	1.096	20.75	8	2.594	3.690	1250	3.0
2.	2.192	20.75	8	2.594	4.786	1250	3.8
3.	3.288	20.75	7	2.964	6.252	1250	5.0
			Fine and Coarse Aggregates				Primary rate per CFC
1.	1.096	20.75	7	2.964	4.060	CFC	4.1
2.	2.192	20.75	7	2.964	5.156	CFC	5.2
3.	3.288	20.75	6	3.458	6.746	CFC	6.7

NOTES :—1. Rates include cost of labour for loading and unloading.
2. Rates are applicable to type 'A' roads—Cemented, Oil bound, and good metalled roads.
3. Add to the above 15, 20 and 30% for class B,C and D type roads respectively.

TYPE :—B. Gravel, kankar and murum roads.
C. Rough metal roads.
D. Soft roads.

8.5. Freight Rates by Trucks over Projects

8.5.1. Study of freight rates over the projects **is limited to a few** projects only. The data given in Table 8.5.1. is for the **different materials** of construction over various leads.

TABLE 8.5.1.

Freight Rates for Different Materials in Rupees

Sl. No.	Name of Project	Lead in miles									
		½	1	2	3	4	5	6	7	8	9
1	2	3	4	5	6	7	8	9	10	11	12
				Rubble Stone per CFC							
1.	Nangal	—	6.5	—	—	—	—	—	—	—	—
2.	Sarda Hydel	—	6.0	—	—	—	—	—	—	—	—
3.	Matatila	—	5.0	9.0	12.0	15.0	17.0	19.0	21.0	23.0	25.0
4.	Mayurakshi	5.0	8.0	10.0	11.9	13.9	15.9	17.9	19.9	21.8	23.8
5.	Hirakud	—	8.0	10.0	12.0	13.5	15.0	16.5	18.0	19.5	21.0
6.	Gangapur	7.0	—	8.9	—	—	—	—	—	—	—
7.	Kakrapar	7.0	—	—	—	—	—	—	—	—	—
8.	Vaitarna	3.8	5.7	—	—	—	—	—	—	—	—
9.	Lower Bhawani	4.4	5.9	8.9	11.9	14.9	17.9	20.9	23.9	26.9	29.0
10.	Malampuzha	—	12.0	—	—	—	—	—	—	—	—
11.	Peechi	—	3.10	—	—	—	—	—	—	—	—
12.	Perinchani	2.6	—	—	—	—	—	—	—	—	—
				Ballast or Aggregate per C.F.C.							
1.	Sarda Hydel	—	—	—	—	—	11.5	—	—	—	—
2.	Matatila	—	5.0	9.0	12.0	15.0	17.0	19.0	21.0	23.0	25.0
3.	Mayurakshi	—	8.3	10.4	12.6	14.6	16.8	—	—	—	—
4.	Hirakud	—	8.0	10.0	12.0	13.5	15.0	16.5	18.0	19.5	21.0

TABLE 8.5.1.—contd.

1	2	3	4	5	6	7	8	9	10	11	12
					Ballast or Aggregate per CFC—Contd.						
5.	Gangapur	—	—	8.9	—	—	—	—	—	—	—
6.	Kakrapar	—	—	—	14.0	—	—	—	—	—	—
7.	Bhadra	—	8.8	13.0	16.6	20.3	24.0	27.7	31.4	35.1	38.8
8.	Lower Bhawani	4.4	5.9	8.9	11.9	14.9	17.9	20.9	23.9	26.9	29.9
9.	Malampuzha	—	8.8	—	—	—	—	—	—	—	—
10.	Peechi	—	3.1	—	—	—	—	—	—	—	—
11.	Perinchani	2.6	—	—	—	—	—	—	—	—	—
					Sand, Shingle and Surkhi per CFC						
1.	Nangal	—	—	9.4	13.6	15.0	—	—	19.3	21.0	—
2.	Sarda Hydel	—	—	—	—	—	11.5	—	—	—	—
3.	Matatila	—	5.0	9.0	12.0	15.0	17.0	19.0	21.0	23.0	25.0
4.	Gandhisagar	—	—	—	—	—	—	9.8	—	—	—
5.	Hirakud	—	8.0	10.0	12.0	13.5	15.0	16.5	18.0	19.5	21.0
6.	Gangapur	—	4.7	8.0	—	—	—	—	—	—	—
7.	Kakrapar*	—	7.0	—	11.0 to 15.0	—	—	—	—	—	—
8.	Lower Bhawani	4.4	5.4	7.4	9.4	11.4	13.4	15.4	17.4	19.4	21.4
9.	Malampuzha	—	—	—	—	—	—	6.4	—	—	—
10.	Peechi	—	—	—	—	—	17.4	—	—	—	—
11.	Perinchani	—	—	—	—	8.5	—	—	—	—	—
					Bricks per 1000 Nos.						
1.	Nangal	—	5.5	—	—	—	—	—	—	—	—
2.	Sarda Hydel	—	—	—	—	—	11.0	—	—	—	—
3.	Matatila	—	5.0	9.0	12.0	15.0	17.0	19.0	21.0	23.0	25.0
4.	Mayurakshi	—	8.0	11.0	13.0	15.0	17.0	19.0	21.0	23.0	25.0
5.	Hirakud	—	8.0	10.0	12.0	13.5	15.0	16.5	18.0	19.5	21.0**
6.	Lower Bhawani	3.5	4.3	5.8	7.3	8.8	10.3	11.8	13.3	14.8	16.3†

* 25.38/10 miles.
** $10'' \times 5'' \times 3''$.
† $8\frac{3}{4}'' \times 4\frac{1}{4}'' \times 1\frac{3}{4}''$.

TABLE 8.5.1—concld.

1	2	3	4	5	6	7	8	9	10	11	12
					Cement per Ton						
1.	Nangal	—	1.0	1.9	2.6	—	—	4.2	—	—	—
2.	Sarda Hydel	—	—	—	—	2.8	—	—	—	—	—
3.	Matatila	—	—	5.0	—	—	—	—	—	—	—
4.	Gandhisagar	—	—	—	—	1.13	—	—	13.6 for 30 miles		
5.	Mayurakshi	—	2.0	2.5	3.0	4.0	4.5	5.0	5.5	6.0	—
6.	Hirakud	—	2.0	2.75	3.5	4.0	4.5	5.0	5.5	6.0	6.5
7.	Gangapur	—	—	—	—	—	10.5 for 15 miles				
8.	Kakrapar	—	—	1.9	—	—	—	—	—	—	—
9.	Lower Bhawani	1.1	1.4	1.9	2.4	2.9	3.4	3.9	4.4	4.9	5.4
10.	Malampuzha	—	—	—	—	—		10.4 for 29 miles.			
11.	Perinchani	—	—	—	—	—	64.1 for 130 miles.				
					Steel per Ton						
1.	Nangal	—	1.2	1.9	—	—	—	—	—	—	—
2.	Sarda Hydel	—	—	—	—	3.7	—	—	—	—	—
3.	Mayurakshi	—	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
4.	Hirakud	—	2.0	2.75	3.5	4.0	4.5	5.0	5.5	6.0	6.5
5.	Lower Bhawani	1.9	2.5	3.6	4.6	5.7	6.7	7.8	8.9	9.9	10.9

8.6. Transport by Steam Loco and Diesel Loco

8.6.1. The excavated soil from the foundation was transported by Steam & Diesel Locos in Tungabhadra and Sarda Hydel Projects. The rates as observed in respective cases are as follows, which are inclusive of loading and unloading charges.

Steam Loco

Sarda Hydel: Rs. 1.0 to 1.25 per CFC per mile.
Tungabhadra (Andhra): Rs. 2.0 per CFC per mile.

Diesel Loco

Sarda Hydel : Rs. 0.75 to 1.0 per mile per CFC
Tungabhadra (Andhra) : Rs. 1.60 per mile per CFC

In the case of Sarda Hydel Project the rates do not include the share of laying and maintaining the track and Rolling Stock whereas in the case of Tungabhadra rates are inclusive of those charges. Rates as observed at Tungabhadra are workable. The full details as observed in Tungabhadra are given in Appendix 5.

8.6.2. The rates of transport of materials will vary with nature of the materials and their weight. Generally most of the materials could be transported at Rs. 0.40 to 0.45 per ton per mile by Steam Loco, and Rs. 0.36 to 0.40 per ton per mile by Diesel Loco.

8.7. HANDLING OF MATERIALS WITH OTHER EQUIPMENTS

8.7.1. Other types of equipment used for handling materials are belts, buckets, ropeway conveyors, etc.

8.7.2. Belt Conveyors are under operation on Bhakra and Panchet Hill Projects. Observed data in the case of Panchet Hill Project and estimated analysis in the case of Bhakra Dam Project are given below :—

PANCHET HILL PROJECT

Operation of Belt Conveyor

Quantity handled : 3,44,000 C.F.T. (Approximate)
Working hours : 1,037

1.	Labour (A) Operation	Rs.	2323
	(B) General	Rs.	610
2.	Labour Field Maintenance	Rs.	472
3.	Material (a) P.O.L.	Rs.	419
	(b) Miscellaneous	Rs.	122
4.	Repairs and Overhauls @ 100% of depreciation.	Rs.	3501
5.	Depreciation at 3.38 per hour	Rs.	3501
6.	Power	Rs.	778
	Total	Rs.	11,726

Rate per CFC of rock. $\frac{11726}{3440}$ = Rs. 3.41

Rate per ton is Rs. 0.77, the lead involved is not likely to exceed 1/4 mile.

The cost of transporting the aggregate in Bhakra Dam is Rs. 0.51 per ton over a distance of 1.55 miles. The details of the estimated analysis are given below :—

Aggregate Transport—Fatehwal to Neilla

	Original Value	%	Residual Value
(*a*) *Plant Depreciation*			
1. Feeder	12,000	20	2400
2. Conveyors No. 3-7 7008′-30″ wide			
Belt	3,70,000		
Idlers	2,00,000		
Drives	1,74,000	10	17,400
Electric Motors	45,000	50	22,500
Total :	8,01,000		42,300
Deduct :	42,300		
Cost chargeable to works	7,58,700		
Depreciation per ton.	$\frac{7{,}58{,}700}{66{,}81{,}800}$		0·111 per ton
(*b*) *Erection plant per ton*	$\frac{7{,}09{,}200}{66{,}81{,}800}$		0·106 per ton
(*c*) *Labour per day*			
4 Foremen @ 20/-	80		
4 Asstt : Foremen @ 12/-	48		
4 Mechanics @ 8/-	32		
8 Greasemen @ 3/-	24		
20 Unskilled Coolies @ 2/8/-	50		
4 Electricians @ 8/-	32		
Total :	266		
Labour per ton	$\frac{266}{6360}$		= 0·042 per ton

(*d*) *Electrical Energy*

340 units @ -/-/10 per unit Rs. 17.7

Electric energy per ton @ 67% $= \dfrac{17{\cdot}7}{6360} = 0{\cdot}003 \times 2/3$

$= 0{\cdot}002$

Total for 1-2

(a)	0·111
(b)	0·106
(c)	0·042
(d)	0·002
(e)	0·207
	0.478 per ton

8.8. Transport by Ropeways

8.8.1. Transport by ropeway is also used at Vaitarna and its data are reproduced below :—

Ropeway :

Length of Ropeway	13,400 ft.
Rise	40
Speed of Hauling Rope	9.2 feet/sec.
Capacity of one bucket	1 ton
Cost of ropeway with all accessories.	Rs. 9,97,000

Rate per ton per 3 miles works out to be Rs. 1.55.

8.8.2. Bokaro Thermal Station (D.V.C.)

The aerial ropeway covers a distance of 5½ miles between Bermo Colliery and the power station. It has been constructed at a total cost of Rs. 26,26,000. The total budget provision including cost of land, site clearing, etc., is Rs. 29.95 lakhs.

The estimated operation and maintenance cost is Rs. 7,51,000 per annum. Assuming 6 years life for the rope, 10 years for the bucket sheeves, etc., and 40 years for land, trestle foundation etc., it is estimated that the cost of transporting coal from the colliery to the Power Station will be about Rs. -/15/- per ton. This works out to Rs. -/2/9 per ton per mile.

DRILLING AND QUARRYING

9.1. Types of Drills

9.1.1. Drills may be divided into two main groups and further sub-divided as shown below :—

- Drills
  - Percussion rock drills
    - Jack hammers or sinkers
    - Drills or Drifters
    - Well or Churn Drills
  - Abrasion Core drills
    - Diamond drills
    - Shot core drills

9.2. Drilling Performances

9.2.1. Table 9.2.1. gives the relative drilling performances for various types and sizes of drills.

TABLE 9.2.1.

Drilling Performance (feet per hour)

		Rock Drills		Core Drills	
Diameter of hole (inches)	Class or rock	Jack-hammer	Wagon drill	Diamond drill	Shot drill
1 (Core 1-1/8)	Soft to	10 to 12	25 to 35	3 to 7	
	medium	5 to 10	20 to 25	2 to 4	
2-3/8 (Core 1-5/8)	Soft to medium	8 to 15	25 to 30		
2-3/8 (Core 1-1/5)	Hard	3 to 8	15 to 25		
3 (Core 2-1/8)	Soft to medium hard				
4 (Core 3)	Soft to		5 to 10		
	medium hard		3 to 5		1 to 2
6 or 5½ with (Core 4-3/4)	Soft to		3 to 6		¾ to 2½
	medium hard		1 to 3		½ to ¾
12	Soft to medium hard		1 to 4		
36	Soft to				½ to 1
	medium hard				¼ to ½

9.2.2. Record of drilling holes for grouting rock foundations in projects have been tabulated in table 9.2.2.

TABLE 9.2.2.

Drilling performance for grouting rock foundations

Sl. No.	Name of Project	Type of rock drilled	Particulars of hole			Use rate per hour of drilling machine	Rate per F.R. in Rs.
			Dia. (in.)	Depth (ft.)	Depth per hr. (ft.)		
1	2	3	4	5	6	7	8
			Jack Hammer				
1.	Bhakra	From sand-stone to silt-stone and other foundation mixed with shale	2½ to 3½	0 to 16 : 16	5.0	42.3	8.5
2.	Matatila	Granite	1.09 to 1.48	0 to 35 : 35	9.4	5.5	
			Core Drill				
3.	Bhakra	From sand-stone and other foundation mixed with shale	1.7/8 A.X. hole	16 to 30 : 14	4.0	79.4	19.8
4.	Bhakra	,,	,,	30 to 150 : 120	3.0	64.0	21.9
5.	Bhakra	,,	,,	150 to 200 : 50	1.6	48.1	30.0
6.	Bhakra	,,	,,	200 to 300 : 100	1.2	43.3	36.1
7.	Bhakra	,,	,,	50 to 100 : 50	5.0	92.0	18.0
8.	Bhakra	,,	3 N.X. hole	0 to 75: 75	2.4	74.7	31.0

TABLE 9.2.2—*contd.*

1	2	3	4	5	6	7	8
9.	Matatila	Granite	1-7/8 A.X holes	3 to 22 & 64 to 75 in depth	1.0	59.0	59.0
10.	Matatila	Granite	2-3/8 B.X. holes	0 to 3 & 42 to 56 in depth	1.0	69.6	69.6
11.	,,	,,	3 X.X. holes	0 to 4 & 32 to 39	1.0	84.4	84.4
12.	Tungabhadra (Andhra)	Epidiorite	$3\frac{1}{2}$	20.3	0.3	5.4	18.0
13.	,,	,,	,,	40.0	0.3	5.2	17.3
14.	,,	White pegmatite	$3\frac{1}{2}$	25.0	0.8	6.1	7.6
15.	,,	Pegmatite	$5\frac{1}{2}$	20.0	0.4	7.1	17.8
16.	,,	Hard epidiorite	$2\frac{1}{2}$	—	0.3	7.3	24.3
17.	,,	Pegmatite	$2\frac{1}{2}$	43.0	0.7	5.9	8.4
18.	Bhakra	Sand-stone and other foundation mixed with shale	36	30.0	0.2	47.0	235.0
19.	Tungabhadra (Andhra)	Pegmatite or epidiorite—		40.0	0.6	9.8	16.2
20.	,,	Epidiorite	$2\frac{1}{2}$	30.0	0.4	6.7	16.8
21.	,,	Pegmatite	$2\frac{1}{2}$	20.0	0.7	6.9	9.9
22.	Tungabhadra (Hyd.)	UCRS masonry	—	—	1.5	16.3	10.7
23.	,,	,,	1-7/8	—	1.5	19.3	12.8
24.	,,	,,	3	—	1.5	24.3	16.2
25.	Matatila	Granite	$2\frac{1}{2}$	0 to 12 : 12	1.5	9.5	6.4
26.	Gangapur	Rock	1 to $1\frac{1}{2}$	—	6.7	26.7	4.0
27.	Tungabhadra (Andhra)	Epidiorite	2 to $3\frac{1}{2}$	18.3	0.6	4.5	7.5
28.	,,	,,	$1\frac{1}{2}$ to $3\frac{1}{2}$	20.0	1.3	5.4	4.1

9.3. Drilling for Blasting

9.3.1. Data regarding drilling for blasting by Jack hammer as furnished by the various projects is given below :—

TABLE 9.3.1.

Jack hammer drilling & Blasting

Sl. No.	Name of Project	Type of rock drilled	Dia. of hole in inches	Full depth of hole in ft.	Depth of hole per hr.	Rate of drilling machine	Rate per F.R. in Rs.
1	2	3	4	5	6	7	8
*1.	Matatila	Granite	1.3	0 to 15	12.5	7.5	0.6
2.	Gangapur	,,	2 to $2\frac{1}{2}$	—	15.8	17.9	1.1
**3.	Vaitarna	Basalt	1.3 to1.5	20	12.5	9.1	0.7

* 6 working hours per shift.
** Assuming shift hrs. to be 3 hrs. labour includes blasting also.

9.3.2. Drilling cost will vary according to the type of rock drilled. A typical analysis of cost of drilling in basalt is given below. In the case of hard and abrasive rock like granite or sandstone the cost will increase by 25 to 30% depending on the nature of rock. About 6 r. ft. of drilling in basalt is required to blast 100 c. ft.

Analysis of Rate for drilling one r. ft. in Basalt

Drilling 20 ft. deep holes from 40 mm. at top to 33 mm. at bottom with Carbide tipped Conomont drills.

(a)	Average set of 3 sets of Conomont drills of different lengths.	Rs.	90
	Average r. ft. drilled by the drills allowing for breakages.		500′
	Cost of drill per r. ft. of drilling.	Rs.	0.18
(b)	Sharpening charge L.S.	Rs.	0.04
(c)	Pipes & pipe fittings	Rs.	0.08
(d)	Machinery charges : Depreciation of Jack hammer @ 3% per month	Rs.	30

Depreciation per hr. @ 200 hrs. per month : Rs. 0.15
(A Jack hammer can drill 100 r. ft. in 8 hrs.)

Depreciation per r. ft.	$\frac{8x0.15}{100}$:	Rs.	0.012
Repairs @ 40% of depreciation		Rs.	0.005

(e) Air Charges:

Using 315 C.F.M. air compressor supplying air to 4 Jack hammers

Use-rate of air compressor :	Rs. 14/-	
Cost of air supplied to 1 Jack hammer		Rs. 3.5
Hence, cost of air for 0.08 hour of Jack hammer per r. ft.		0.08x3.5 Rs. 0.28

(d) Labour per r.ft. : Rs. 0.11

Abstract

(a)	Cost of drill	Rs.	0.18
(b)	Sharpening charges	Rs.	0.04
(c)	Pipes & pipe fittings	Rs.	0.08
(d)	Machinery charges	Rs.	0.017
(e)	Air charges	Rs.	0.28
(f)	Labour	Rs.	0.11
	Total rate of drilling per r. ft.	Rs.	0.707

9.4. Air Compressors

9.4.1. The portable diesel compressors commonly used are of 210, 315 and 500 c ft. per minute capacity. Stationary compressors particularly the electrical ones are preferable to the portable types on large works). Detailed analysis of use rates of air compressors is given below (Table 9.4.1 .

TABLE 9.4.1.

Air Compressor—Portable

210 *CFM Diesel Compressor* ; (55 *H.P.*)

(a)	Cost of compressor	Rs.	25,100
	Life in working hours.		10,000
	Depreciation per working hour.	Rs.	2.61
(b)	Repairs & Maintenance cost @ 80% of depreciation		2.09
(c)	P.O.L. charges		
	2.25 diesel oil & Rs. 1.5 per gal.		3.40
	Lubricants & grease.		0.75
	Sundries such as cotton waste, etc.		0.75
			4.90

(*d*) Labour charges

½ No. driver @ Rs. 4.5 per day per shift.		0.30
1 No. helper @ Rs. 3.0 per day per shift.		0.40
		0.70
Add 25 % for idle days and leave reserve labour rate per working hour.		0.18
	Rs.	0.88

Abstract

Depreciation	Rs.	2.61
Repairs & maintenance		2.09
Fuel charges		4.90
Labour charges		0.88
		10.48

Use rate per working hour: 10.48 say Rs. 10.5

315 *GFM Diesel Compressor* (78 *h.p.*)

(*a*) Depreciation per working hour :		
Cost of the compressors	Rs.	38,300
Life in working hours.		10,000
Depreciation per hour.	Rs.	3.83
(*b*) Repairs & maintenance @ 80% of depreciation charges.	Rs.	3.07
(*c*) P.O.L. charges		
3 Gls. Diesel oil @ Rs. 1.5 per gal.		4.50
Lubricants and grease.		1.00
Sundries such as cotton waste, etc.		0.75
	Rs.	6.25
(*d*) Labour charges :		
½ No. driver @ Rs. 4.5 per day per shift.		0.30
1 No. Helper @ Rs. 3 per day per shift.		0.40
		0.70
Add 25% for idle days & leave reserve		0.18
Labour rate per working hour.		0.88

Abstract

Depreciation	3.83
Repairs & Maintenance	3.07
Fuel charges	6.25
Labour	0.88
Use rate per working hour.	14.03 Say Rs.14/-

500 *CFM Stationery Electric Compressor.*

(*a*) Depreciation per working hour :		
Cost of the compressor	Rs.	31,200
Depreciation @ 1% per month		3.12
Assuming 26 days in a month and 8 hrs. per shift per day *i.e.*, 200 working hours, depreciation rate per working hour $\frac{312}{200}$	Rs.	1.56

(*b*)	Repairs & maintenance @ 80% of depreciation rate.	Rs.	1.25
(*c*)	Power charges		
	Rated h.p. of the engine: 120 h.p.		
	Power consumption per hour 89.5 KWh at full load.		
	Power charges for 89.5 KWh @ Rs. 0.125 per unit		11.2
	Lubricants & other sundries.		0.8
	Total power & oil charges per hr.		12.00
(*d*)	Labour charges		
	½ No. operator @ Rs. 6/- per day per shift.		0.38
	1 No. Helper @ Rs. 3/- per day per shift.		0.38
	½ No. Foreman @ Rs. 12/-. per day per shift.		0.38
	Chowkidar @ Rs. 1.75 per day of 2 shifts		0.11
			1.25
	Add 25% of for non- working season & leave reserve.		0.31
	Labour charges per hour.		1.56

Abstract

Depreciation		1.56
Repairs & maintenance		1.25
Power charges		12.00
Labour		1.56
Use rate per working hour 16.37 say	Rs.	16.50

500 *CFM Diesel Compressor* (127 *H.P.*)

(*a*)	Depreciation per working hour	
	Cost of the compressor	58,000
	Life in hours	10,000
	Depreciation per hour	5.8
(*b*)	Repairs & maintenance @ 80% of depreciation	4.64
(*c*)	P.O.L. Charges	
	4.5 gls. of diesel oil @ 1.5	6.76
	Lubricants & grease	1.00
	Sundries such as cotton waste	0.75
		8.50
(*d*)	Labour charges.	
	½ No. driver @ Rs. 4.5 per day per shift	0.30
	1 No. helper @ Rs. 3/- per day per shift	0.40
	Add 25 % for idle days and leave reserve	0.18
		0.88

Abstract

Depreciations	5.80
Repairs & maintenance	4.64
Fuel charges	8.50
Labour charges	0.88
	19.82

Use rate per working hour Rs. 19.82 say Rs. 20/-

9.4.2. Table 9.4.2. shows an abstract of the foregoing table 9.4.1.

TABLE 9.4.2.

Abstract of the Use Rates of Compressors

Sl. No.	Type	Size	Rate per working hour: Depreciation	Repairs etc.	Fuel etc.	Labour	Use rate per hour	Cost of 1000 cft. of air
1.	Diesel portable.	210 CFM	2.6	2.1	4.9	0.9	10.5	0.83
2.	-do-	315 ,,	3.8	3.1	6.2	0.9	14.0	0.74
3.	-do-	500 ,,	5.8	4.6	8.5	0.9	19.8	0.66
4.	Electrical Stationery	500 ,,	1.6	1.3	12.0	1.6	16.5	0.55

9.4.3. The use-rates of air compressors, used on some of the projects from which information became available, are tabulated in Table 9.4.3.

TABLE 9.4.3.

Use Rates of air compressors used on Projects

Sl. No.	Project	Rate per working hour: Depreciation	Repairs	Fuel etc.	Labour	Use rate per working hour	Remarks
	1. *Diesel Portable* 315 CFM						
a.	R.&.C.C.	3.8	3.1	6.2	0.9	14.0	
b.	Bhakra	3.9	6.3	6.2	1.1	17.5	
c.	Gandhisagar	3.7	5.0	3.0	1.6	13.3	
d.	Kotah Barrage	2.8	2.8	5.2	3.1	13.9	Assuming 100% of depreciation
	2. *Diesel Portable* 500 *CFM*						
e.	R.&.C.C.	5.8	4.5	8.5	0.9	19.8	
f.	Bhakra	4.5	7.2	5.6	1.1	18.4	Portable compressor
	3. *Electrical Stationery* 500 *CFM*						
g.	R.&.C.C.	1.6	1.3	12.0	1.6	16.5	
h.	Gandhisagar	2.3	1.7	12.0	2.1	18.1	

9.4.4. Variations are mainly due to non-standard practices and it is suggested that the method of arriving at use rates shown in the Table 9.4.1. should be adopted on all the projects.

9.5. Air Consumption of Pneumatic Tools

9.5.1. Table 9.5.1. gives the air consumption of pneumatic tools operated by compressed air. Consumption is expressed in c. ft. of free air per minute, at 90 PSI and standard conditions.

TABLE 9.5.1.

Air Consumption of Pneumatic Tools

S.No.	Tool	CFM
1.	Drills, rock	
	Jackhammers	
	30 lb. weight	60
	45 ,,	85
	55 ,,	95
	80 ,,	125
	Augurs	85
2.	Drifters (Wagon drills)	
	65 lbs. weight	125
	100 ,,	156
	140 ,,	200
3.	Hoists, 500-1000 lbs. capacity 1.5 (consumption/ft. of lift)	
	2000 lb.	2.0
	3000 lb.	3.0
	4000 lb.	6.5
	6000 lb.	8.5
4.	Pavement Breakers	
	30 lbs. weight	45
	55 ,,	50
	85 ,,	75
5.	Sump Pumps	
	Upto 100 ft. head	65
	Upto 185 ft. head	115
6.	Tampers, backfill	
	25 lbs. weight	30
	38 ,,	35
7.	Trench diggers	
	25 lbs. weight	35
	45 ,,	45

9.6. Blasting

9.6.1. When rock excavation or stone quarrying is to be done on a large scale, blasting would cost less per 100 cubic feet by means of machine drills and dynamite than by hand drills and gunpowder. Ordinarily, however, the cost is about the same, and the advantage in the addition of the former method lies in better speed, convenience and good control.

Details of materials and amount of labour required for blasting 100 c. ft. of basalt rock are given below :—

TABLE 9.6.2.

	Analysis of rates for blasting Rock	Rs.
1.	Gelatine, 2.25 lbs. at Rs. 1.5 per lb.	3.38
2.	Detonators 4 Nos. at Rs. 6 per 100 Nos.	0.24
3.	Labour	
	3.1 Blaster 0.01 at Rs. 4.5 each	0.05
	3.2 helper or quarry } 0.20 at 3.5 each	0.70
		4.37

Say Rs. 4.50

9.6.3. The building stones suitable for hydraulic works are the harder type such as quartzite, granite, trap and basalt weighing 140/145, 165,180 and 185 lbs. per cu. ft. respectively. Table 9.6.3. indicates their use on the various masonry dams recently built or under construction.

TABLE 9.6.3.

Name of Dam	Type of stone	specific gravity
Gandhisagar, Kotah Barrage, Jawai Konar Tilaiya Panchet	Quartzite (Vindhyan & stone) and Gondwane sandstone	140 (2.24) 140/145 (2.4)
Maithon Hirakud Matatila Tungabhadra Bhadra Tunga anicut Peechi, Perinchani Lower Bhawani Malampuzha	Granite	165 (2.65)
Vaitarna Gangapur Kakrapar	Basalt and trap	185 (2.88)

9.7. Comparative Rates for Rock Excavation

9.7.1. Comparative statement of rates per CFC for rock excavation on various projects is given in table 9.7.1. (i).

TABLE 9.7.1. (i).

Actual Rates of Rock Excavation per CFC on Projects

Sl. No.	Project	Type of rock	Rate per CFC of Rock Rs.		
			Drilling	Blasting	Total
1	2	3	4	5	6
1.	Bhakra	Mixed Rock	2.54 / 4.20	5.60 / 4.50	8.44 / 8.70
2.	Gangapur	Deccan trap	4.32 / 4.20	3.52 / 4.50	7.84 / 8.70
3.	Gandhisagar	Highly abrasive foliated quartzite	15.77 / 12.60	6.45 / 6.60	22.22 / 19.10
4.	Kakrapar	Deccan trap	4.75 / 4.20	6.0 / 4.5	10.75 / 8.70
5.	Kotah	Laminated quartzite	5.97 / 4.20	3.26 / 4.50	9.23 / 8.70
6.	Peechi	Granite	8.00 / 6.30	5.75 / 5.62	14.75 / 11.92
7.	Vaitarna	Basalt	3.53 / 4.20	7.03 / 4.50	10.58 / 8.70

NOTE—The above figures in each line are as per R. & C. C.

CHAPTER 10

TUNNELLING

10.1. Cost Study

10.1.1. The cost study for tunnelling has been divided into two portions, namely, rock excavation and concrete lining and the data has been collected from the following four projects :—

1. Ramsagaram Tunnel (Tungabhadra Project)
2. Bhakra Dam Diversion Tunnels (Punjab)
3. Bhor and Thal Ghat Tunnels (Central Railway)
4. Budni Barkhera Tunnel (Central Railway)

10.2. Ramsagaram Tunnel

10.2.1. The tunnel is in the shape of a horse-shoe with vertical sides of 8′-3″ and 16′ diameter semi-circular roof, inverted bed 1 ft. below the flat bottom. It is built for the passage of water for irrigation purpose. The particulars are given below :—

Length	1105′
Height, finished	17′-3″
Height, excavated	19 feet to 20 feet.
Width, finished	16 feet.
Width, excavated	18′-8″ to 20′-0″
Area, finished	246 square feet.
Area, excavated	313 to 340 square feet.

Area of waterway	204 square feet
Area of lining	67 square feet (minimum)
Lining (with masonry and concrete)	
Bottom (invert)	9″ thick, 1:3:5 C.C.
Sides	1′-4″ thick, 1:3:5 C.C. and R.R. Masonry in 1:6 C.M. Plastered smooth in 1:4 C.M. $\frac{3}{4}$″ thick.
Top arch	1′-0″ from spring level in 1:3:5 C.C.
Full supply depth	13.25 feet
Fall	1/1250
Velocity	8.75 feet per second
N (Coefficient of friction)	0.014
Discharge	1785 Cusecs
Discharge required	1745 Cusecs

10.2.2. The "Method of Driving" the tunnel adopted was bottom heading in one stage and stopping the top in second stage. The "Drilling Pattern" adopted was generally the "Burns Cut" and with $7\frac{1}{2}$ feet depth of drill holes, an advance of $5\frac{1}{2}$ to 6 feet per round was obtained. "Blasting" was done by the use of delay action detonators, fired electrically. These were of half a second interval delay action. "Mucking" was done mostly manually and partly by a mine loader, with one cu. yard trucks on double line of tram track pushed by manual labour from inside, out of the tunnel into the open cut from where the trucks were hoisted up by derricks and further pulled by Diesel Loco to the unloading site. The muck had to be hoisted up only as bed excavation was in progress in the approach flumes.

10.2.3. The cost of tunnel excavation works to Rs. 238.5 per CFC of designed cubic contents of the tunnel, and Rs. 207 per CFC of actual excavated quantity. Expenditure on preliminaries and experimental work done has been excluded. Items 8 and 9 of the data table 10.2.4. relate to expenditure on special supports and protective works used to deal with the loose rock met with, not anticipated originally at the time of estimating.

10.2.4. The analysis of expenditure on the Ramsagaram tunnel is given in Table 10.2.4.

TABLE 10.2.4.

Sl. No.	Particulars	Rate of rock excavation (actual) per CFC (Rs.)	Total Expenses (Rs.)
1	2	3	4
1.	Installation & transshipment of 25-ton derrick in the rear face, 4-ton derrick in the front face & cranes for loading & unloading.	4.9	19,200
2.	Laying of tramway track including preparing the tracks at site and transshipment from various places, the trucks hooks and rails.	6.9	27,000
3.	(a) Installation of water supply arrangements including conveyance of pantoon tanks & cost of pipe line.	2.9	11,500
	(b) Maintenance of water supply including the water tanker 1500 gallons capacity for $1\frac{1}{2}$ years.	5.4	21,300
4.	(a) Installation of Air compressor including testing, connveyance and transshipment.	0.5	2,100
	(b) Laying 6″ & 4″ compressed air mains, from compressor house to the front & rear faces and initial laying inside the tunnel including the cost of 6″ & 4″ pipes & their conveyance from Headworks and freight.		
	6″ Pipe line Rs. 8,700		
	4″ ,, ,, Rs. 8,800		
	Total 17,500		
	Credit for Pipes		
	6″ Pipes Rs. 4,800		
	4″ Pipes Rs. 6,000		
	10,800	1·7	6,700
5.	Installation of ventilating equipment including the cost of conveyance & cost of 10″ diameter air ducts Rs. 10,900.		
	Deduct cost of 10″ diameter Pipes $600 \times 8 = \frac{\text{Rs. } 4,800}{\text{Rs. } 6,100}$	1.6	6,100
6.	Installation of Drill sharpening equipment.	0.3	1,200
7.	(a) Installation of electrification including transporting the generator to site.	3.4	13,300
	(b) Maintenance.	10.3	40,000

Table 10.2.4.—*contd.*

1	2	3	4
8.	(a) Temporary wooden supports for the roof from L.S. 168 to 190 in the rear face for loose portion.	1.7	6,500
	(b) Steel centering from L.S. 210 to 226 in the rear face : 19,300 Credit 1500×7= 10,500 8,800	2.2	8,800
	(c) Temporary supports to the piolt tunnel from 226 to 260.	0.5	2,000
	(d) Temporary supports at L.S. 380	0.1	300
9.	Steel supports for crevice roof supports from L.S. 210 to 236	2.5	9,700
10.	Manufacturing drilling accessories and staging and bending blow pipe, etc.	1.1	4,100
11.	Removing of bed muck & clearing the under-breakages.	2.1	8,300
12.	Tunnel dewatering (Special)	1.7	6,800
13.	Share of Excavation of tunnel by contractor.	103.00	4,03,900
14.	Petty supervision.	11.1	33,000
15.	Photographic & accident expenses.	2.3	9,150
16.	Cost of machinery tools & spares debited to the work. Cost of machinery & tools: Rs. 1,86,197 Cost of spares 92,367 2,78,564 Credits 1,68,500 1,10,064	25.2	1,10,064
17.	(a) Machinery sheds, stores sheds Rs. 34,290 Credits expected 5,000 29,290	7.5	29,290
	(b) Sheds for Foreman, Drillers, Masons, Carpenters & Labour 33,900 Credits 520 33,380	8.5	33,380
	Total	207.3	8,14,084

10.3. BHAKRA DIVERSION TUNNEL

10.3.1. The two tunnels have been excavated at Bhakra, one on each side of the river for diversion of the river water for constructing the dam. The rock met with varied from jointed sandstone to indurated clay. The method adopted for excavation was heading and bench method of mucking and drilling in which drilling could proceed on the heading while the bench was being mucked. The quantity of explosive used was 3.5 lbs. average per CFC of excavated material in the two tunnels.

10.3.2. The following statement (10.3.2.) shows the working rate of excavation of the left diversion tunnel (as supplied by the Project authorities for departmental work from 16.10.50 to 30.4.53).

TABLE 10.3.2.

Sl. No.		Description	Rate per CFC (Rs.)
1		2	3
1.		*Labour*	
	(*i*)	Excavation including drilling, blasting and barring.	21.0
	(*ii*)	Labour for ribbing including welding and packing.	3.7
	(*iii*)	Timber erection and dismantling.	1.1
	(*iv*)	Mucking, *i.e.*, working of shovels, Euclids and Dumpers, etc.	13.1
	(*v*)	Cost of explosives.	6.9
	(*vi*)	Clearing dumping site by bulldozers.	2.1
	(*vii*)	Stock and lubricant.	1.3
	(*viii*)	Laying pipe line & maintenance.	0.4
	(*ix*)	Accidents.	0.6
	(*x*)	Hutting.	Nominal
2.		*Material*	
	(*i*)	Timber.	3.7
	(*ii*)	Steel including fabrication.	30.5
3.		*Machinery*	
	(*i*)	Compressed air.	9.9
	(*ii*)	Lighting charges including stock & work charges	6.6
	(*iii*)	Depreciation of machinery	4.6
	(*iv*)	Repair to jack hammers, jack rods including working of drill sharpening machine.	1.1
4.		*Miscellaneous*	
	(*i*)	Ramps and paths.	0.9
	(*ii*)	Pumping including electric charges.	6.8
5.		*Supervisory charges*	
	(*i*)	Tunnel foreman, pay and allowance.	1.8
	(*ii*)	Work charged establishment.	1.3
	(*iii*)	Contingencies.	0.8
		Total	118.2

10.3.3 Detailed analysis of rate for rock excavation in the right dam tunnel as provided by the project is given in table 10.3.3.

TABLE 10.3.3.

		Expenditure per month
A. Labour.		
For six wagon drills and six jack hammers.		
(*i*)	Drillers on 6 wagon drills for 2 shifts. @ Rs. 108 p.m. $=6\times2\times2\times108$	(Rs.) 2,592
	Fitters in 6 wagon drills for 2 shifts @ Rs. 108 p.m. $=6\times2\times1\times108$	1,296
	Drillers for jack hammers @ Rs. 108 p.m. $=6\times3\times2\times108$	3,888
(*ii*)	*Blasting labour*	
	2 Blasters @ Rs. 108 p.m.	216
	2 Helpers @ Rs. 65 p.m.	130
	10 skilled *mazdoors* for making tamping balls @ Rs. 65 p.m.	650
(*iii*)	*Laying and linking Pipe line*	
	For 2 shifts Pipe fitters @ Rs. 95 p.m. $=2\times1\times95$	190
	Skilled *mazdoors* @ Rs. 65 p.m. $=2\times2\times65$	260
(*iv*)	*Making paths and ramps inside the tunnel*	
	Work mistri for 2 shifts @ Rs. 80 p.m. $=2\times1\times80$	160
	Skilled coolies for 2 shifts Rs. @ 65 p.m. $=2\times10\times65$	1,300
(*v*)	*Supervisory and other staff for two shifts*	
	1 Foreman @ 360 p.m. $=2\times1\times360$	720
	2 Supervisors @ Rs. 120 p.m. $=2\times2\times120$	480
	8 Work mistris @ Rs. 100 p.m. $=2\times8\times100$	1,600
	2 *Chowkidars* @ Rs. 52 p.m. $=2\times2\times52$	208
	2 Store Attendants @ Rs. 52 P.M. $=2\times2\times52$	208
	8 Fitters @ Rs. 108 p.m. $=2\times8\times108$	1,728
	4 *Khalasis* @ Rs. 50 p.m. $=2\times4\times50$	400
	15 Muckers @ Rs. 68 p.m. $=2\times15\times68$	2,040
	1 Gubliman @ Rs. 75 p.m. $=2\times1\times75$	150
	1 Time keeper @ Rs. 100 p.m. $=2\times1\times100$	200
	Total.	18,416

Total Labour expense per month : Rs. 18416

$\therefore$ Labour expense per day, assuming 25 working days in a month. $=\frac{18,416}{25}$ Rs. 736.6

B. Materials

(*i*)	Repairing parts of 6 jack hammers and 6 wagon drills @ Rs. 0.5 per hour per machine for 5 hours $=12\times5\times0.5$	30.0
(*ii*)	6 Bits for 6 jack hammers @ Rs. 2.5 each $=6\times2.5$	15.0
	6 Forged bills for 6 wagon drills @ Rs. 1.5 each $=6\times1.5$	9.0
(*iii*)	Rods worth Rs. 40,000 work issue for 72,65,700 F.C. of rock excavation.	

Hence per CFC $=\frac{40,000}{72,657}=0.55$

TABLE 10.3.3.—*contd.*

	Hence per 6,000 F.C. @ 0.55 per CFC		33.75
(*iv*)	Lubrication for 12 machines @Rs. 0.75 per machine per shift.		9.0
(*v*)	*Explosives*		
	20 wagon drill holes @ 8 lbs. each	160 lbs.	
	30 wagon drill holes @ 6 lbs. each	180 lbs.	
		340 lbs.	
	Cost of 340 lbs. @ Rs. 2.0 per lb.		680.0
Detonators			
	For 20 wagon drill holes @ 2 Nos. each	40	
	For 30 jack hammers hole @ 1 No. each	30	
		70	
	7 Nos. detonators @ 0.75 each		52.5
	Total cost of material per day of 2 shifts.		829.25

C. Machinery Charges

Total rock excavated : 222 Cyds.
As one Euclid carries $3\frac{1}{2}$ Cyds.
∴ No. of Euclids : $222 \div 3\frac{1}{2}$: 64 Nos. $\frac{64}{6}$
One Marion Shovel can run 6 Euclids per hour.

Hence working hours of shovel$= \frac{64}{6} = 11$ hours

As one dumper takes 20 minutes for disposal of loaded muck,	
∴ Working period of dumper$=64\times20/60$: 22 hours.	
∴ Cost of working of marion shovel for 11 hours @ Rs. 40/- per hour.	440
Cost of working dumpers 22 hours @Rs. 22 per hour.	484
Dozer for levelling etc. of muck for 12 hours @ Rs. 34 per hour.	408
∴ Total Machinery charges per day of 2 shifts.	1,332

D. Supply of air charges

6 hours working of 6 wagon drills
& 6 Jack hammers is assumed.
Each wagon drill takes 300 CFM/hour.
∴ Air consumed$=6\times6\times300=$10,800 C.F.M.
Each Jack hammer takes 150 C.F.M./hour,
∴ Air consumed$=6\times6\times150=$ 5400 C.F.M.

Total. =162,00 C.F.M.

TABLE 10.3.3.

E. Other workshop charges

1 Chargeman per shift for 2 shifts @ Rs. 140 p.m. $=2\times1\times140$	280
4 Fitters per shift for 2 shifts @ Rs. 108 p.m. $=2\times4\times108$	864
4 Khalasis per shift for 2 shifts @ Rs. 65 p.m. $=2\times4\times65$	520
Total	1,664
∴ Workshop charges per day $=1664/25$	66.5

10.3.4. Abstract of expense per day of 2 shifts

1.	Labour charges.	Rs. 736.60
2.	Materials—Petty Stores & Explosives.	Rs. 829.25
3.	Machinery charges.	Rs. 1332.00
4.	Air charges.	Rs. 486.00
5.	Other workshop charges.	Rs. 66.50
		3450.35
	Add 25% due to breakdown of machinery, lights pumping & air	862.59
	Total	4312.94

Say Rs. 4313

Output is 6000 F.C. or 222 Cyds. per day
∴ Rate per C.F.C. or rock excavators $=4313/60$ Rs. 71.9

Say Rs.72 per C.F.C.

10.4. Bhor & Thal Ghat Tunnel

10.4.1. The tunnelling work involved in Bhor & Thal Ghat was carried out under contract and therefore no analysis of rates is available. However, the construction of these tunnels was carried out in connection with the doubling of Budni-Barkhera line on Itarsi-Bhopal section and was carried out through the departmental agencies. The details of cost as

supplied by the Central Railway are given in table 10.4.1. The method employed consisted of driving a pilot tunnel and then enlarging later after the pilot was completed.

TABLE 10.4.1.

Sl. No.	Type Section	Heading			Enlarging		
		Qty. in cft.	Rate per 100 cft. (Rs.)	Cost (Rs.)	Qty. in cft.	Rate per 100 cft. (Rs.)	Cost (Rs.)
1	2	3	4	5	6	7	8
1.	Crown lined single line tunnel wholly on straight and without side lining (cost per ft. length).	64	160	102	416	160	666
2.	Crown lined single line tunnel wholly on straight with side lining (cost per ft. length).	64	160	102	566	160	906
3.	Straight portion of crown lined single line tunnel is partly on straight and partly on curve 50 and without side lining (cost per ft. length).	64	160	102	426	160	682
4.	Straight portion of crown lined single line tunnel where tunnel is partly on straight and partly on curve 50 and without side lining (cost per ft. length).	64	160	102	586	160	938
5.	Crown lined single line tunnel on curve 50 and without side lining (cost per ft. length).	64	160	102	466	160	746
6.	Crown lined single line tunnel on curve 50 and with 64 side lining (cost per ft. length).	64	160	102	616	160	986
7.	Unlined single line tunnel on straight (cost per ft. length)..	64	160	102	296	160	474
8.	Unlined single line tunnel on curve 50 (cost per ft. length).	64	160	102	321	160	514
9.	Portal for unlined tunnel on 50 curve (cost per ft. length).	—	—	—	295	160	472
10.	Cost of man refuge in an unlined tunnel.	—	—	—	182	160	292
11	Cost of trolly refuge in an unlined tunnel.	—	—	—	1100	160	1760

10.5. Budni Barkhera

10.5.1. In the Budni Barkhera Tunnel a statement has been extracted based on the job costing done by the Railway Department as shown in table 10.5.1.

TABLE 10.5.1.

	Depreciation		Pilot Heading Rs.	Top half Breakout Rs.	Benching lower half Rs.
a.	Labour in drilling & blasting.		12 6 0	6 3 0	4 8 0
b.	Drilling tools replaced.		3 2 0	2 11 0	2 3 0
c.	Explosives.		18 15 0	9 1 0	8 0 0
d.	Mucking labour.		19 0 0	21 3 0	14 13 0
e.	Proportionate cost of Jambo for drillings. (1880/-)		1 3 0	—	—
f.	Multipurpose shield in top half break-out (4200/-)		—	1 6 0	—
g.	Support work.		18 10 0	53 7 0	2 0 0
h.	Mechanical services for compressed air, water & lighting.		17 10 0	10 9 0	8 4 0
i.	Lighting charges.		11 8 0	9 12 0	5 0 0
j.	Proportionate ownership and maintenance cost per shift.		15 9 0	12 8 0	5 3 0
	Plant compressor.	14 1 0			
	Generator.	4 1 0			
	Pneumatic tools.	9 0 0			
	Pump.	4 0 0			
		31 2 0			
k.	Workshop services.		13 0 0	7 10 0	5 7 0
l.	Accommodation of labour, offices, etc.		14 0 0	14 0 0	14 0 0
m.	Supervision at site.		8 11 0	6 8 0	3 0 0
			153 10 0	154 14 0	72 6 0

Cost per Lft. of Tunnel excavation.	Proportionate cost
Heading area 106 sq. ft.	162 14 0
Top half breakout 208 sq. ft.	322 2 0
Lower half benching 263 sq. ft.	190 6 0
Total	Rs. 675 6 0

Cost per 100 cft. of Tunnelling Excavation=117/-

10.6. Lining of Tunnels

10.6.1. The cost of erection of temporary supports of either timber or steel has been included in the rates for excavation already discussed in the preceding paragraph.

10.6.2. Table 10.6.2. gives details of the cost of cement concrete lining for Bhakra diversion tunnels and Budni-Barkhera railway tunnels.

TABLE 10.6.2.

Sl. No.	Specification	Bhakra		Budni Barkhera (Central Rly.)
		Right Diversion Tunnel	Left Diversion Tunnel	
1	2	3	4	5
1.	Coarse Aggregate			
	(a) Quantity per CFC	0.9	—	0.8
	(b) Amount in Rs.	21.8	16.1	28.8
2.	Fine Aggregate			
	(a) Quantity per CFC	0.4	—	0.5
	(b) Amount in Rs.	7.0	12.8	11.7
3.	Cement			
	(a) Quantity in cwts.	14.3	—	18.0
	(b) Amount in Rs.	58.8	70.7	90.0
4.	Total cost of material	87.6	99.5	129.7
5.	Cost of labour	24.0		
6.	Miscellaneous cost	31.1	88.0	*131.5 & 109.5
7.	Share of Plant cost	26.4		
8.	Rate of cement concrete per CFC	167.0	187.5	*341.3 to 319.3

*The higher rate of lining is for arch roof of Tunnel and lower rate for sidewalls.

10.6.3. Table 10.6.3. shows primary cost of cement concrete lining per CFC in other projects. Details are not available.

TABLE 10.6.3.

Sl. No.	Project	Rate per CFC		
		Lining of sides	Lining of arch roof	Overall average
1.	Ramsagaram.	—	—	332
2.	Bhore Ghat.	261	385	—
3.	Thal Ghat.	186	355	—

BRICKWORK AND LINING OF CANALS

11.1. Price of Bricks

11.1.1. The price of bricks varies from Rs. 20/- to Rs. 30/- per thousand of standard well-moulded and well-burnt common bricks while the rates for the larger size varies from Rs. 35/- to Rs. 45/-. These prices are ex-kiln and cost in transporting would be proportional to the haulage involved.

11.1.2. Standard size of bricks in most parts of the country is 9″ × 4-3/8″ × 2-11/16″ so that 4 courses and 4 joints of brickwork would rise to 12″ height. In some Statse and in Irrigation department the brick size is 10″ × 5″ × 2¾″. Joints vary from ¼″ to ½″. Tolerances of 1/8″ in length and 1/16″ in other directions are common.

11.1.3. The number of standard bricks per CFC of brickwork shall vary with the size of bricks and the quantity of mortar used or thickness of mortar joints. Table 11.1.3. gives the number of standard bricks required per CFC for various thicknesses of mortar joints.

TABLE 11.1.3.

Number of Bricks per CFC (exclusive of wastage)

Size of brick	Thickness of joints		
	1/4″	5/16″	3/8″
9″ × 4-3/8″ × 2-11/16″ (Standard brick)	1350	1300	1270
10″ × 5″ × 2¾″	1040	1000	975

11.2. Mortar Materials

11.2.1. Mud is the cheapest binder and will continue to be used and ought to find favour on the construction of camps which are likely to be demolished and the salvaged bricks utilised elsewhere. Regarding other binders it may be stated in general, that cement improves the strength

of mortar while lime improves its workability. The use of lime along with cement in the mortar is said to aid the retention of moisture in it for the more complete hydration of cement in the mix and also to introduce a high degree of plasticity enabling handling of mortar with ease and providing a uniform bedding for the bricks.

11.2.2. The quantity of dry mortar mix required for 1000 bricks and per CFC of masonry in a 1½ brick wall has been tabulated below in table 11.2.2. for various thicknesses of joints. Allowance has been made for normal wastage in mortar.

TABLE 11.2.2.

Mortar (in cft.) for brickwork in 1½ brick wall (Standard bricks)

Thickness of joints in inches	1/4"	5/16"	3/8"
Mortar per 1000 bricks	14	17	21
Mortar per CFC of brickwork	19	22	25

11.2.3. Brick walls usually would require relatively less or more mortar per unit of brickwork depending on their thickness. If mortar content for 1½ brick wall is taken as 1000 then the relative indices of mortar required for other thicknesses of brickwalls may be applied from the following table 11.2.3.

TABLE 11.2.3.

Thickness of walls in brick sizes	½	1	1½	2	2½	3
Percentage indices for mortar	92	95	100	103	105	108

11.2.4. Weights of materials used and mortar are given below :—

(1)	Stone-lime in small lumps from kiln.	44	lbs.	per	FC
(2)	Fine and dry pit sand	90	,,	,,	,,
(3)	Medium sand	95	,,	,,	,,
(4)	Coarse sand	100	,,	,,	,,
(5)	Ashes	50	,,	,,	,,
(6)	Lime-sand mortar 1:2 to 1:3 proportion	114	,,	,,	,,
(7)	Cement-sand mortar 1 : 3 hand made stiff well mixed.	124	,,	,,	,,
(8)	Cement-coalash mortar 1 : 2 mixed stiff and fresh	107	,,	,,	,,

11.2.5. The quantities of the various ingredients of mortar are given below :—

TABLE 11.2.5.

Type of mix	Ratio	Ingredients per FC				Labour mixing/FC man-day
		Cement Cwts.	Lime Mds.	Sand FC	Surkhi FC	
LSM	1:2	—	.27	1.0	—	.012
	1:3	—	.20	1.1	—	,,
	1:4	—	.15	1.2	—	,,
CLM	1:1:4	.21	.14	1.0	—	.015
	1:1:6	.15	.10	1.1	—	,,
	1:1:8	.12	.08	1.2	—	,,
CS	1:2	.40	—	1.0	—	.012
	1:3	.29	—	1.1	—	,,
	1:4	.22	—	1.2	—	,,
	1:5	.21	—	1.3	—	,,
RCM	4:1:10	.34	—	1.0	.08	.02
	4:1:15	.25	—	1.1	.06	,,
	4:1:20	.19	—	1.2	.05	,,

L = lime, S = Surkhi

11.3. Prices of Mortar Materials

11.3.1. Prices will vary at different times and in different localities, *e.g.*, sand may cost anything like Rs. 5/- to Rs. 15/- CFC (average Rs. 10/-), stone lime from Rs. 1/8 to 4/- per md. (average Rs. 3/- per md.) and cement Rs. 4/8 to Rs. 6/- (average Rs. 5/-) at different places.

11.3.2. The data for labour and plant needed for mortar mixing are given in the table 11.3.2.

TABLE 11.3.2.

Nature of Mortar	Plant hour per CFC	Labour days per CFC
Lime, Sand (LSM)	4	1.00
Cement, Lime, Sand (CLM)	4.5	1.25
Cement, Sand (CM)	5	1.33
Cement, Surkhi, Sand (RCM)	6.0	1.50
Lime; Ashes or Surkhi	6.5	1.66

11.3.3. Cost of mortars per F.C. hand mixed and those of mechanically mixed are indicated below. The prices have been derived on the basis of assumed wages and rates.

TABLE 11.3.3.

Cost of Mortars per FC mixed by (a) Manual Labour (b) Mechanical Mixing

Type of Mix	Ratio	Material	Labour	Cost per FC
		(a) *Manual labour for mixing.*		
LSM	1:2	0.91	0.021	0.93
	1:3	0.71	0.021	0.73
	1:4	0.57	0.021	0.59
CLM	1:1:4	1.57	0.029	1.60
	1:1:6	1.16	0.029	1.19
	1:1:8	0.96	0.029	0.99
CM	1:2	2.10	0.021	2.12
	1:3	1.56	0.021	1.52
	1:4	1.22	0.021	1.24
RCM	4:1:10	1.80	0.035	2.20
	4:1:15	1.36	0.035	1.40
	4:1:20	1.07	0.035	1.11
		(b) *Mechanical mixing.*		
LSM	1:2	0.91	0.06	0.97
	1:3	0.71	0.06	0.77
	1:4	0.57	0.06	0.63
CLM	1:1:4	1.57	0.07	1.64
	1:1:6	1.16	0.07	1.23
	1:1:8	0.96	0.07	1.23
CM	1:2	2.10	0.073	2.173
	1:3	1.56	0.073	1.633
	1:4	1.22	0.073	1.293
RCM	4:1:10	1.80	0.086	1.886
	4:1:15	1.36	0.086	1.446
	4:1:20	1.07	0.086	1.166

11.4. Labour Output in Brickwork

11.4.1. The number of bricks laid per day or cubic feet of masonry performed per day per mason will depend upon the kind of brick face, thickness of joints, quality of mortar, thickness of wall, number of openings corners, panelling pillars, working conditions, etc. Table 11.4.1. gives range and average number of bricks laid per person per day for common straightforward brickwork.

TABLE 11.4.1.

Approximate rate of laying bricks for heights not exceeding 10′ (*common brickwork*)

Thickness of Wall	No. of bricks laid with struck joints (per day per mason)					
	On one face			On two faces		
	From	To	Average	From	To	Average
1	2	3	4	5	6	7
1. ½ Brick wall	300	500	400	250	400	325
2. 1 ,, ,,	400	600	500	300	500	400
3. 1½ ,, ,,	500	800	650	400	600	500
4. 2 ,, ,,	600	1000	800	500	700	600
5. 2½ ,, ,,	700	1200	950	550	750	650
6. 3 ,, ,,	800	1400	1100	600	800	700

11.4.2. The amount of work done per day by a helper can be any one of the following items.

1. Mix 100 to 120 F.C. of mortar.
2. Deliver 3000 to 5000 bricks to a distance of 50′.
3. Deliver mortar 150 to 250 F.C.
4. Two good helpers can handle 100 to 200 ton of pole staging.

11.5. Cost of Scaffolding (use and waste)

11.5.1. Cost of scaffolding (use and waste) may be reckoned as a percentage on the cost of bricks to be laid or as a unit rate per CFC of brickwork. For single storey houses it would be Rs. 0.5 to 1.0 per CFC of brickwork depending on the thickness of walls.

11.6. Cost of Brick Masonry

11.6.1. It can be readily understood that different rates would be required for different classes of brickwork for varying positions, conditions and specifications. The Committee do not propose to examine all those items relating to brickwork.

11.7. Lining of Canals

11.7.1. It has been possible on several projects in India to reduce the section of the canal, and, also to make a considerable saving in seepage losses by lining the channels with an impervious material.

11.7.2. While canal lining is a new feature in India it has been in practice for a long time in other countries like U.S.A., where the entire work is mechanised and carried out in cement concrete resulting in speedy construction. In India, however, the work has so far been done entirely by manual labour using especially moulded brick tiles, or stone-slabs or cement concrete to suit local conditions.

11.7.3. The prominent examples of this class of work are the Harike Canal, Nangal Hydel Canal, Sarda Hydel Canal and the Tungabhadra Canal.

11.7.4. The data collected for these projects has been analysed in the following tables 11.7.4. (i), (ii) and (iii).

TABLE

Basic Rates of Constituents

Sl. No.	Name of Project	Rates of materials in rupees (Issue Rates): Cement Cwt.	Tiles or Bricks 1000 Nos.	Stone Slab 2" thick CFS	1½" Aggregate CFC	¾" Aggregate CFC	Sand CFC
1	2	3	4	5	6	7	8
1.	Nangal Hydel Canal (Concrete 1:3:6)	4/12/-	—	—	9/-/-	12/-/-	2/-/-
2.	Nangal Hydel, Rupar (Tile Size 12"×6"×2")	4/7/-	41/-/-	—	—	—	2/-/-
3.	Sarda Sagar (Brick Size 10"×5"×2½")	5/4/-	29/4/-	—	—	—	3/-/-
4.	Harike (Tile Size 12"×6"×2")	4/9/-	42/-/-	—	7/8/-	12/5/-	1/15/-
5.	Tungabhadra (Andhra)	5/4/-	—	25/12/-	20/-/-	42/1/-	25/-/-
6.	Tungabhadra (Hyd.)	5/4/-	—	28/5/-	—	34/-/-	17/2/-

NOTES: 1. The rates of materials do not include carriage and are issue rates.
2. Sand is River Sand and its lead in case of Tungabhadra (Andhra) is 26 miles.
3. Sand Lead for Tungabhadra Project (Hyd.) is not given.

TABLE

Break up of Rates of Brick

Sl. No.	Name of Project	Mix of Mortar	Brick Tiles: Qty. Nos.	Rate inclusive of carriage per 1000 Nos.	Amount (Rs.)	Sand: Qty. in FC	Rate inclusive of carriage per CFC	Amount (Rs.)
1	2	3	4	5	6	7	8	9
1.	Nangal Hydel (Rupar) 12"×6"×2" Double Layer Tile lining in bed.	1:4 c.m.	908	51.75	47.16	36.3	16.0	5.83
2.	-do- on slopes.	1:4 c.m.	908	51.75	47.16	36.3	16.0	5.83
3.	Harike 12"×6"×2" Double Layer Tile lining in bed.	1:4 c.m.	908	47.0	42.68	36.3	6.5	2.36
4.	Sarda Sagar Hydel 10"×5"×2½" Double Layer Tile lining in bed and slopes.	1:4 c.m.	1100	39.25	43.18	40.0	10.0	4.00

Break up of rates of U.C.R.S.

	Tungabhadra (Hyd.) 9" thick U.C.R.S. in slopes.	1.8 c.m.	100	10.29	10.29	40.0	11.14	4.46.

11.7.4. (*i*)

for Canal Lining at Projects

Carriage rates (Rs.)		Carriage rates over long leads		Mixer charges per CFC. Rs.	Mixer charges per hour Rs.	Weighted average wage rate Rs.	Remarks
Per Ton for 1st Mile	Per CFC 1st Mile	Per Ton per Mile	Per CFC per Mile				
9	10	11	12	13	14	15	16
1/1/-	6/8/-	-/8/-	1/-/-	2/11/-	—	2.3	
1/1/-	6/8/-	-/8/-	1/-/-	—	—	2.3	* Rates by trolley excluding depreciation & laying Trolley. Mixer use rate @ Rs. 3/-/- is equal to Rs. 2/11/- per CFC with 10/7 mixer.
—	—	*1/-/-	*1/8/-	—	—	2.3	
1/-/-	6/8/-	-/7/10	-/15/-	—	—	2.3	
1/10/-	5/4/-	—	—	—	—	1.8	
1/1/-	4/-/-	—	—	9/6/-	3/-/-	1.8	

11.7.4. (*ii*)

Tile lining rate per CFC

Cement			Labour	Soaking Tank curing & water Arrange-ments	T & P Sundries pro-file for Sub-grade	Total rate in Rs. per CFC. 100 CFT	Rate in Rs. CFS. 100 Sq. ft.	Thick-ness of lining	Remarks
Qty. in cwt.	Rate inclusive of carriage per cwt.	Amount (Rs.)							
10	11	12	13	14	15	16	17	18	19
7.95	4.59	36.49	25.8	5.9	—	121.2	53.37	5″	(1) Excess Labour for slope lining Rs. 4.75 per CFC.
7.95	4.59	36.49	32.4	5.9	9.13	136.94	60.33	5″	
7.95	4.77	37.95	23.25	—	—	106.25	47.12	5″	(2) Rate for CFS on slope Rs. 49.2
7.40	5.5	40.70	38.60	—	5.5	132.00	66.00	6″	
Masonry lining (Rate per CFC).									
3.98	5.57	22.17	25.12	—	—	62.00	46.5	9″	

TABLE 11.7.4. (*iii*)

Break up of Rates of Concrete Lining rate per CFC

Sl. No.	Item	Nangal Hydel Canal		Tungabhadra (Andhra)		Tungabhadra (Hyderabad)	
		5″ thick in bed	6″ thick in slopes	4½″ thick in bed	4½″ thick in slopes	4″ thick in bed (Blasting of Agg: by Govt.)	Precast c.c. Slab 2″ thick
1.	Mix of Concrete	1:3:6	1:3:6	1:6:10	1:3½:5	1:6:10	1:4:5
2.	a. Aggregates ½″ size, Quantity in FC.	46.6	47.0	77.1	77.7	100	86.7
	Rate inclusive of carriage per CFC.	24.26	24.26	40.06	40.06	—	34.3
	Amount (Rs.)	11.3	11.4	30.9	31.1	12.86	29.4
	b. Aggregates ¾″ size, Quantity in FC.	46.6	47.0	19.3	19.4	—	—
	Rate inclusive of carriage per CFC.	27.26	27.26	54.0	54.0	—	—
	Amount (Rs.)	12.7	12.9	10.9	10.5	—	—
3.	Sand, Quantity in FC.	46.6	47.0	57.8	58.2	50.0	69.0
	Rate inclusive of carriage per CFC.	18.06	18.06	35.0	35.0	17.16	10.3
	Amount (Rs.)	8.4	8.5	20.2	20.4	8.58	7.5
4.	Cement, Quantity Cwts.	12.68	12.70	7.74	13.52	6.66	13.9
	Rate inclusive of carriage.	4.85	4.85	5.15	5.15	5.35	5.57
	Amount (Rs.)	61.5	61.6	39.9	69.6	35.67	76.5
5.	Labour	15.17	19.75	10.3	31.2	26.1	143.1*
6.	Plant use	2.75	2.75	2.72	16.8	—	9.37
7.	Form work	13.7	20.0	—	33.8	—	—
8.	Slurry	17.9	15.0	15.6	16.5	—	—
9.	Curing	1.8	1.5	—	—	4.3	—
10.	Sundries	—	—	—	—	0.73	—
11.	Total Rate (Rs.) per CFC. AV.	145.2 149.3	153.4	130.0	229.9	889.3	265.8
12.	Rate (Rs.) per CFS. AV.	61.0 68.85	76.7	48.75	87.75	29.6	44.12

* Includes (i) labour for concreting, (ii) fixation of blocks. (iii) 1 : 6 c.m. mortar, quantity of which is not given, (iv) conveyance of precast slabs.

Rates include washing of aggregates also.

STEEL WORKS AND GATES

12.1. Hydraulic Gates

12.1.1. Hydraulic gates can be classified into :—

(i) Category 1, where the operating member moves on sliding surfaces, or

(ii) Category 2, where the operating member moves on wheels or rollers, or

(iii) Category 3, where the operating member rotates about a fixed or movable point to engage with the sealing element.

12.1.2. Ordinary low head and bulk head gates belong to the first category and are the most common. For higher heads, mounting of wheels and rollers becomes necessary to keep down frictional resistance in the operation of gates. Radial and Drum gates are examples of the third category and are used for regulating the flow over the spillway.

12.1.3. All these types of gates are built essentially in steel with a lining on the water face. The allied structures comprise the operating platforms, bridges, hoists and the controlling devices.

12.2. Indigenous Manufacture

12.2.1. Until lately, all gates and hoists for the River Valley Projects used to be imported from abroad at a prohibitive cost. Recently, however, the technique of steel fabrication has developed so fast in the country, both in the public and private sectors, that there is hardly any need now for the import of such structures.

12.2.2. Notable examples of the public enterprise are Government Workshops at Amritsar, Madras, Izatnagar (U.P.), and the Tungabhadra Project which have turned out quality products at competitive rates. In the private sector, a number of reputable firms exist in the country which can undertake such jobs on competitive prices, but their chief difficulty in the past has been that they do not get sufficient load for their shops due to preference shown to foreign manufacturer. It is, therefore, recommended that a Central Agency should watch the interests of this important engineering undertaking in the country, both in the private and the public sectors.

12.2.3. Table 12.2.3. indicates the extent of work done within the country. Fuller details are given in appendix (9).

TABLE 12.2.3

Sl. No.	Name of project	Nature	Year of Manufacture	Cost per ton		Hoisting Gear	Total
				Gate Leaves	Embedded parts		
1	2	3	4	5	6	7	8
				Rs.	Rs.	Rs.	
1.	Nangal Dam	Regulator	1954	—	—	—	1,340
2.	Tilaiya, D.V.C.	Spillway	1952	—	—	—	4,200
3.	Bokaro, D.V.C.	Spillway Emergency	1952 1952	—	—	—	2,600
4.	(*i*) Kopai (Mayurakshi)	Weir Sluice Regulator	1950 ,, ,,	—	—	—	1,700
	(*ii*) Dwarka (Mayurakshi)	Weir Sluice Regulator	1951 ,, ,,	—	—	—	1,400
	(*iii*) Bakraswar (Mayurakshi)	Crest Sluice Regulator	1951 ,, ,,	—	—	—	2,000
	(*iv*) Brahmani (Mayurakshi)	Weir Sluice Regulator	1953 ,, ,,	—	—	—	2,150
5.	(*i*) Hirakud (Mani Dam)	Spillway	1955	—	—	—	2,000
	(*ii*) Hirakud Bargarh canal	Regulator	1955	2,900	1,400	18,000*	4,300
6.	Tungabhadra	Spillway Sluice Penstock	1952-54 1952-53 1953-54	1,360 4,600 4,800	800 1,600 1,620	45,000* 57,600* 64 500*	2,160 6,100 6,420
7.	Jawai	Spillway	1954-55	1,450	1,000	16,000*	2,450
8.	Lower Bhawani	Spillway	1954	5,216	1,528	13,200*	6,744

**Pro rata* share of the hoisting gear is not included.

12.3. Break-up of cost

12.3.1. Statements showing break-up of cost of manufacturing gates, etc. in the Tungabhadra and Amritsar Workshops are given below : Tables 12.3.1. (i) & 12.3.1. (ii) :--

TABLE 12.3.1. (*i*)

Statement of Break up of cost of Hydraulic gates
(*Manufactured by* : Tungabhadra Workshop)

Sl. No.	Details of Gate	Steel %	Other material and consumables	Labour %	Centage charges %	Percentage of centage over labour col. 6/5×100
1	2	3	4	5	6	7
	Gate Leaf					
1.	Bargarh Sluice Gate, Hirakud Project.	$17\frac{1}{2}$	$19\frac{1}{2}$	37	26	70
2.	Low level Sluice Gate, Tungabhadra.	10	28	35	27	77
3.	Penstock Gate, Tungabhadra Project.	$10\frac{1}{2}$	40	30	20	67
4.	Jawai Spillway Gates, Rajasthan.	40	13	22	25	114
5.	Spillway Gates, Tungabhadra Project.	33	28	19	20	105
	Embedded Metal					
6.	Bargarh Sluice embedded parts, Hirakud.	36	20	18	36	144
	Hoist					
7.	Bargarh Hoist, Hirakud.	14	34	27	25	93
	Operation Bridge					
8.	Operation Bridges, Tungabhadra Project.	45	12	18	25	139

TABLE 12.3.1. (*ii*)

Statement of Break-up of cost of Nangal Canal Head Regulator Gates
(*Manufactured by* : Government Central Workshops, Amritsar)

Sl. No.	Details of Gate	Material (Steel) %	Labour %	Centages charges	Percentage of Centage over labour (Col: 5/4 x 100)
1	2	3	4	5	6
1.	Canal Head Regulator Gates, Nangal	47	12	41	342

12.3.2. The Executive Engineer incharge of the Tungabhadra workshop reports that item (2) low level sluice gate for Tungabhadra was the first one manufactured in the shop when the cost worked out to Rs. 4600 per ton. Subsequently with improved methods it was possible to make similar sluice gates @ Rs. 2900/- per ton although the basic rates for steel had increased during the period.

12.4. THE OVERHEAD CHARGES

12.4.1. The overhead charges comprising factory charges in the various shops, general charges and office charges with direct labour base are also shown in the previous table, but a further split up is given in table 12.4.1. for Amritsar Workshop.

TABLE 12.4.1.

Workshop Overhead Charges in percentages over cost of Direct Labour

For quarter ending 3/55
(Govt : Central Workshops, Amritsar)

S.l No.	Name of Shops	Direct Labour	Percentages of Overhead (Actual)			
			Factory	General	Office	Total
1	2	3	4	5	6	7
1.	Machine shop	100	481	148	43	672
2.	Tool Room & Heat Treatment shop	100	140	33	43	216
3.	Steel & Welding shop	100	181	88	43	312
4.	Smithy shop	100	181	82	43	306
5.	Iron & Brass foundry	100	190	91	43	324
6.	Mill wright shop	100	311	122	43	476
7.	Carpenter shop	100	148	64	43	255
8.	Painter shop	100	93	46	43	182
9.	Fitter shop	100	159	61	43	263
10.	Factory as a whole	100	234	92	43	369

12.5. DETAILS OF ACTUAL EXPENSE

12.5.1. Details of actual expense on various elements for gates manufactured in the three shops are recorded.

TABLE 12.5.1.(*i*)

Tungabhadra Workshop

A. Low Level Sluice

1. Project	Tungabhdra
2. Type of Gate and purpose served.	Low level Sluice gate Fixed wheel Life Gate

TABLE 12.5.1. (*i*)—*contd.*

3. Size	6′ × 12″
4. Maximum lead for which designed.	83′
5. Type of water seals	Music note for side seals and flat rubber bottom.
6. Whether rollers provided, if so what type, fixed or moving	Fixed Rollers
7. Weight of Gate Leaves	9½ tons including 3 tons ballast.
8. Weight of embedded parts	21 tons (with C.I. Lining)
9. Cost per ton of embedded parts	Rs. 1500/- (including C.I. Lining)
10. Cost per ton of Gate leaves	Rs. 4600/-
11. Type of Hoisting Gear provided and the method of operating the same	Hope drum, Hoist power & manually operated.
12. Capacity of Hoisting Gear	30 tons
13. Cost of Hoisting Gear per ton of weight and per ton of capacity	Rs. 4000/- per ton. Rs. 1920/- per ton.
B. Emergency Embedded Parts	
a. 1. Weight	5½ tons
2. Cost	Rs. 7,000/-
3. Cost/ton	Rs. 1,273/-
Emergency Gates	
b. 1. Weight	9 tons each
2. Cost	Rs. 30,000/-each
3. Cost per ton	Rs. 3,333/-
C. High Level Sluice—50 *ft. head*	
1. Vent size	6ft. × 12ft.
2. Total weight of sluicegate, hoists and built in parts	20 tons
3. Total cost	Rs. 64,000/-
4. Cost per ton	Rs. 3200/-
D. Penstock Cut-off	
1. Penstock (Diam.)	11 ft.
2. Discharge	760 cusecs
3. Power developed	9000 K.W.
4. Nominal size of gate	10½ ft. × 17 ft.
5. Weight of built-in parts	12 tons
6. Weight of gate including hoists	20 tons
7. Weight of 2 speed hoists 30/40 ton capacity	10 tons
8. Total weight of all above	42 tons
9. Total cost	Rs. 1,38,000/- (including erection)
10. Cost per ton of total weight	Rs. 3,280/-
E. Spillway Gates	
1. Size	60 ft. × 20 ft.
2. Discharge	19,000 cusecs
3. Weight of built-in parts	10 tons
4. Weight of operation bridge	18 tons
5. Weight of gates	49 tons
6. Weight of chain hoists 25/35 tons capacity	12 tons
7. Weight of gates, built-in parts, operation bridge and hoists	39 tons
8. Total cost	Rs. 1,64,400/-
9. Cost per ton	Rs. 1,850/

12.5.1. (*ii*) *Madras P.W.D. Workshop*

A. Embedded steel-work for Grooves at sides and still beams for the surplus Gates for the Lower Bhawani Project

Size of Gates.		40 ft. × 20 ft.
1. Steel materials 100 cwt. @ 23/- per cwt. (approx.)		Rs. 2300/-
2. Other materials such as bolts and nuts, paint, electrodes etc. including handling charges.	L. S.	Rs. 1,400/-
3. Labour (Fitter, Welder, Turner, etc.)		Rs. 1,400/-
4. Machine and forges		Rs. 460
5. Centage (Indirect charges)		Rs. 2,150/-
6. Contingencies		Rs. 330/-
Total for vent		Rs. 7640/-
Weight of each unit		5 tons.
Total for 1 vent		Rs. 7,640/-
Cost per ton		Rs. 1,528/-

B. Manufacturing Surplus Gates for vents 36′-0″
excluding Roller Assembly and Posts

1. Steel materials 536 cwt. @ 21/8/-cwt. average	Rs. 11,524/-
2. Other materials such as rivets, bolts and nuts, paint, electrodes etc. including handling charges.	Rs. 4,711/-
3. Labour (Fitter, Welder, Blacksmith Rivetter etc.) contingencies etc. and including general charges @ 30%	Rs. 14,300/-
4. Materials storage 1%	Rs. 165/-
Total cost	Rs. 30,700/-
Total weight	26.8 tons
Cost/ton	Rs. 1,144/-

C. Manufacturing Post Frames at Madras for one vent.

1. Steel material 55.4 cwt. @ 22/-cwt.	Rs. 1,226/-
2. Other materials, such as electrodes, paints holts and nuts, etc. including handling charges	Rs. 834
3. Labour (Fitter, Turner, Welder, Machanics)	Rs. 1,020/-
4. Machining	Rs. 200/-
5. Centage (Indirect charges)	Rs. 1,354/-
6. Centingencies	Rs. 366/-
Total for one vent	Rs. 5,000/-
Total weight	2.77 tons
Cost/ton	Rs. 1,805/-

D. Manufacturing Roller Assembly at Madras Workshop for one vent.

1. Steel materials	Rs. 200/-
2. Direct debit for bearing	Rs. 340/-
3. Labour (Fitter, Mechanic etc.)	Rs. 40/-
4. Machining	Rs. 15/-
5. Centage (Indirect charges)	Rs. 50/-
6. Contingencies	Rs. 51/-
Total for one set of rollers	Rs. 650/-

E. Manufacturing Roller Path Assembly at Madras Workshop.

1. Steel materials 120 cwt. (approx.) @ Rs. 21/8/-cwt.	Rs. 2,580/-
2. Other materials such as bolts and nuts, electrodes, paint, etc. including handling charges.	Rs. 1,959/-
3. Labour (Fitter, Welder, Machanics)	Rs. 1,840/-
4. Centage (Indirect charges)	Rs. 2,423/-
5. Machining	Rs. 500/-
6. Contingencies	Rs. 398/-
Total	Rs. 9,700/-
Cost per ton	Rs. 1,617/-

F. Top Deck Bridge for Hoist Gear Manufactured at L.B.P. Workshop.

1. Steel materials cost (184 cwt) @ Rs. 21/8/- per cwt.	Rs. 3859/-
2. Other materials such as paints, electrodes, including handling charges.	Rs. 738/-
3. Storege	Rs. 46/-
4. Labour charges including general charges, (Fitter Welder, Painter etc.)	Rs. 3380/-
5. Contingencies, 30%	Rs. 1,014/-
Total for one vent	Rs. 9,037/-
Total weight	9.2 tons
Cost per ton	Rs. 982/-

G. Hoist Gear complete Assembly at Madras Workshop for one vent.

1. Steel materials 90-3/4 cwt. @ Rs. 22/8/- cwt. average	Rs. 2,042/-
2. Other materials such as bolts and nuts, rivets, paints, electrodes etc. including handling charges.	Rs. 4,768/-
3. Labour (Fitter, Welder, Turner etc).	Rs. 1,820/-
4. Machines for forges	Rs. 900/-
5. Centage (Indirect charges)	Rs. 3,116/-
6. Contingencies	Rs. 554/-
Total for one vent	Rs. 13,200/-
Total weight	4.54 tons
Cost per ton	Rs. 2,900/-

H. Transport and conveyance including loading etc. for one vent.

1. From P.W. Workshop, Madras to Railway wagon at Salt Containers loading and unloading	Rs. 980/-
2. Rly. Freight for about 1,8,3,15 cwt. or say 60 tons	Rs. 2,600/-
3. Loading & unloading at Mottupalayam at site.	Rs. 200/-
4. Mottupalayam to site @ Rs. 84 for trip 20 trips.	Rs. 1,680/-
5. Contingencies	Rs. 40/-
Total for one vent	Rs. 5,500/-
Weight	59 tons
Cost per ton	Rs. 93/-

J. Erection.

1. Labour (Foreman, Fitter, Erector, gang *mazdoor* etc.) for six months.	Rs. 5,340/-
2. Erection materials such as Manilla rope, pulleys etc.	Rs. 660/-
	Rs. 6,000/-
Cost per ton	Rs. 102/-

TABLE 12.5.1. (*iii*)

Amritsar Workshop

Statement showing weight and rates per ton of Gates and Hoists

Sl. No.	Item	Approx. weight in tons	Rate per ton	Rate per sq. ft. for gate area
1	2	3	4	5
1.	Canal head Regulator, Nangal.	831.5	1341.0	367.0
2.	Nangal Dam	6200.0	1420.0	373.0
3.	Silt Ejector @R.D. 9575-N.C.H.	31.0	1668.75	165.0
4.	Silt Ejector @R.D. 72720-UBDC mainline	20.75	1733.5	100.0
5.	Gates & Gearing for Escapes Charn Ganga	61.0	1823.2	145.0
6.	-do- canal Charan ganga	105.0	1640.6	88.0
7.	-do- Canal Nakian Drainage Syphon	100.0	1814.4	90.0
8.	-do- Escape -do-	62.0	1831.6	140.0
9.	Automatic Radial Gate for Ganguwal Spill-way for Power House No. 1	147.0	3322.0	630.0
10.	Draft Tube Gate for Ganguwal P.H. No. 1	109.0	1362.5	100.0
11.	Gates & Gearing for Bhakra Canals	Flat Rate.		155.0
12.	Intake Radial Gate for Ganguwal Power House No. 1	213.0	1707.0	188.0

STONE MASONRY

13.1. Stone Masonry Classification

13.1.1. Stone Masonry can be classified under the following heads:—

1. Rubble stone masonry, composed of rough undressed stone as it comes from the quarry.

2. Hammer dressed & square stone masonry comprising stones squared and dressed on beds and joints by means of hammers. The stones may be laid in course straight, broken, or random.

3. Ashlar or cut stone masonry is generally used for face work. It may or may not be laid in courses.

4. Dry stone masonry in which no mortar is used. Riprap, pavements, retaining and breast walls are examples.

13.1.2. The various classes of masonry are generally used in combination on works *viz.* the face masonry of dams is laid in squared stone or ashlar and the hearting comprises the uncoarsed rubble. Combined rates of masonry to include classes of masonry and pointing (Table 13.1.2.) show that stone masonry dams built in the last decade have cost Rs. 125 to 233 per CFC.

13.2. Uncoarsed Rubble Stone Masonry

13.2.1. Uncoarsed rubble masonry forms the bulk in a stone masonry dams. Table 13.2.1. gives the comparative primary and overall rates of U.C.R. hearting masonry for the various projects. A detailed statement is appended (Appendix 10).

13.3. Estimating Stones

13.3.1. The units of measurement for all kinds of masonry is CFC (%CFT). The quantity of rough rubble stone per CF in a rubble masonry wall is 120 cft. but in case of large dams where the mortar used is considerably more than that in ordinary walls the quantity or rough stone required is about 100 F.C. of which 2/3rd may be large

TABLE

1. *Projects under*

Sl. No.	Name of Project	Height of dam above A.O. Bed level / Foundation	Qty. of Masonry in CFC Executed	Primary rate in lakhs			
				Hearting EXPR	Face in Lakhs	Pointing	Total in Lakhs
1.	Matatila	— / 110′	115150*	(127.3)	—	0.5	127.8
2.	Hirakud	200′ / 130′	92129	—	—	—	129.0
3.	Bhadra	245′ / 187′	36200	—	—		45.4
4.	Gandhisagar	212′ / 202′	2486000	—	—	—	—

13.1.2.

Execution

Combined primary rate per CFC	On cost	Total cost per CFC	Remarks
110.8	(15%) 16.6	127.4	* Qty. as per latest revised estimate for complete DAM (2 stages). Amount also as per Revised Estimate. R.R. Masonry in C.M. 1:4 ; 1:5. Actual expr. qty. executed so far is not available. On cost %age is based on this latest revised estimate figs. (for indirect & overhead charges.)
140.0	(30%) 42.0	182.0	Figs. are as per estimate-contract rate for R.R. work in Power Dam is Rs. 75 per CFC. Cement supplied free by the Department. For extra lead & lift over the initial lead & lift extra rate is paid. For face work also, extra amount is paid. On cost %age is as per estimated figures.
125.4	(35%) 44.0	169.4	Amount & Qty. executed is as per Proforma IV (actual). Period not given. R.R. Masonry in Lime Surkhi Mortar 1:4 proportion. The primary rate does not include lift charges (P. 312) On cost %age is as per estimated figure.
133.86	(22%) 29.45	163.3	Qty. is as per actual executed—Primary Rate is as per analysis given by the Project authority for R.R. in R.C.M. 1:2-3/4. Rate is without any lift charges. Work is still in initial stage. These are two proportions executed *viz.* R.R. in R.C.M. 1:2-3/4 & 1:4. On cost %age is as per estimated figure.

TABLE

2. *Projects*

Sl. No.	Name of project	Ht. of Dam above bed level / Foundation	Qty. of Masonry in CFC executed	Primary Rate in Lakhs: Hearting EXPR	Face in lakhs	Pointing	Total in lakhs
1.	Kakrapar	601′ / 451′	22951	26.3	3.0	—	29.6
2.	Mayurakshi	155′ / —	90450	—	—	—	112.43
3.	Tungabhadra (And.)	160′ / 150′	152608	—	—	—	264.3
4.	—do— (Hyd.)	160′ / 150′	152608 (assumed)	—	—	—	293.23
5.	Lower Bhavani	204′ / 140′	131722	141.2	14.3	1.3	156.7
6.	Peechi	— / 130′	19912	—	—	—	37.30
7.	Perinchani	—	17762	17.25	0.33	0.2	17.78

13.1.2.

Completed

Combined Primary Rate per CFC	On cost	Total cost per CFC	Remarks
			Figures & Qty. and amount is as per proforma II (actual) supplied by the Project. On cost percentage is based on etimated figures.
128.8	(45%) 58.0	186.8	R.R. in C.H. 1:4
124.3	(20%) 24.86	149.16	Qty. Amount is as per latest figure sent on 23/11/55 by S.E. On cost percentage is as per estimated figure R.R. Masonry in various R.C.M. 1:2-3/4 to 1:5. On cost percentage is as per estimated figure.
173.18	(35%) 60.6	233.78	Qty. & Amount are as per Andhra. On cost percentage is as per estimated figure. R.R. Masonry in R.C.M. 1:2-3/4, 1:4, 1:5 ; Lime Surkhi mortar 1:1:1, 1:2:2; and face stone masonry.
192.2	(35%) 67.27	259.47	Amount as is per Ex. Engr. in 4/54. Reservoir constn. Dn. On cost percentage is as per estimated fig. R.R. in R.C.M. 1:2-3/4, 1:4 and Face Stone Masonry.
119.9	(19%) 22.6	141.6	Qty. & Amount are as per Proforma IV (actual) Figs. are not final as the final adjustments are still to be made on various expr. On cost is as per estimated fig. R.R. Masonry in C.M. 1:6, 1:2, 1:5, 1:4, 1:2-3/4; & R.C.M. 1:5, 1:4, 1:2-3/4, and Face masonry. On cost percentage is as per estimated figure.
187.3	(12.25%) 23.0	210.3	Qty. & Amount is collected by Sri Varadharajan (Actual). On cost %age is as per Sri Varadharajan's calculations. R.R. in C.M. 1:2-3/4, 1:5, 1:4, Face stone work.
100.1	(44%) 44.0	144.1	Qty. & Amount as per Proforma IV (actual) On cost %age is as per actual fig. R.R. in C.M. 1:2-1/2, 1:3, 1:4, 1:5 & 1:6 and Face Stone Masonry.

TABLE 13.2.1.

Rates of U.C.R. Masonry on River Valley Projects

Sl. No.	Projects	1:2-$\frac{3}{4}$ RCM		1:4 CM		1:4 RCM		1:5 CM	
		Primary rate per CFC	Overall rate per QFC	Primary rate per QFC	Overall rate per CFC	Primary rate per CFC	Overall rate per CFC	Primary rate per CFC	Overall rate per CFC
1	2	3	4	5	6	7	8	9	10
1.	Matatila.	—	—	—	—	—	—	99	111
2.	Gandhi Sagar.	131	154	—	—	112	131	—	—
3.	Hirakud.	—	—	139	163	—	—	—	—
4.	Kakrapar.	—	—	—	—	93	126	—	—
5.	Tungabhadra (Andh.).	134	181	—	—	116	157	—	—
6.	—do— (Hyd.).	165	223	—	—	148	200	—	—
7.	Lower Bhawani.	104	117	100	111	100	111	95	105
8.	Malampuzha.	104	124	94	111	—	—	88	103
9.	Peechi	—	—	170	185	—	—	147	160
10.	Perinchani	—	—	87	115	—	—	78	102

NOTE : U.C.R. Masonry in mortars other than those specified above being of relatively small quantities have been deleted from our study.

slightly dressed stone and 1/3rd as small stones and spalls. The quantity and weight of stones used per CFC would depend on the individual and collective volume of large stones and on their density. The larger the size of the individual stones the greater would be the quantity of stone going into the masonry and the heavier the density the greater the weight to be handled.

13.3.2. The waste of stone in case of veneer would be as much as 20% in cutting and dressing at site while there would be very little in the case of rubble masonry provided the stone is passed at the quarry. For the same reason that concrete aggregate should be graded, the stone should also be of all sizes from spalls to the largest that can be economically handled.

13.3.3. The quantities of stone and other constituents used for CFC masonry for hearting of dams are given in Appendix 10.

13.4. Cost of Stone

13.4.1. The cost of stone per CFC in **stacks** at the quarry site for a number of projects has been given below—

TABLE 13.4.1.

Comparative Statement of quarrying rubble (Stack measurements) per CFC

Sl. No.	Projects	Nature of work	Drilling labour	Drilling total	Blasting material	Blasting labour	Mucking	Grand Total Rs.
1	2	3	4	5	6	7	8	9
1.	Matatila	Hard granite	0.45	2.96	4.95	0.416	—	16.32
2.	Mayurakshi.	—	—	—	—	—	—	17.8
3.	Hirakud.	Granite	4.44	5.54	2.83	9.58	—	17.95
4.	Tungabhadra (Andh.)	,,	3.50	4.22	1.04	6.56	3.0	14.82
5.	Tungabhadra (Hyd.).	Granite free to veins & cracks	3.213	0.51	2.71	7.51	1.05	14.78
6.	Bhadra.	—	—	5.0	4.00	1.00	13.00	23.0
7.	Lower Bhawani.	Hard granite	—	—	—	—	—	8.23
8.	Malampuzha.	,,	—	—	—	—	—	11:00
9.	Perinchani.	Hard & tough granite	—	—	—	—	—	14.13

13.4.2. Table 8.4.5. gives an analysis of figures for carriage of stone from quarry to site of work.

13.4.3. Cost of dressing of stone for coarsed masonry will vary with the types of masonry which are described in para 13.1.1. and is included under respective labour constants. The quantity of rough stone required for coarsed masonry would be 150 F.C. for ordinary walls.

13.5. Mortar for Hydraulic Works

13.5.1. The proportions for the mortar used in stone masonry may vary from 1:2 to 1:5 for cement mortar, 1:1:3, 1:1:4, 1:1:5 and 1:1:6 for cement, lime and sand mortar to 1:2:4, 1:2:5, 1:2:6 to 1:2:9 when large proportion of lime is desired. Proportions are by volume, although there is a tendency to introduce proportions by weight. When *surkhi* is used as an admixture to cement it is known as red cement mortar. Generally, *surkhi* powder finely ground is mixed in the proportion 1 : 14 in cement quantity. Measures of sand is for dry sand only. If the sand is wet, bulkage allowance must always be taken into account.

13.5.2. The amount of mortar required will depend on the size of individual stone and the type of masonry. Table 13.5.2. gives minimum and maximum quantities of mortar required per CFC of masonry depending on the size of individual stones used.

TABLE 13.5.2.
Mortar per CFC masonry (UCR)

Kind of masonry	Mortar in (F.C.) per CFC Masonry		
	From	To	Average
1	2	3	4
Rubble	40	50	45
Squared-stone coarsed	25	40	32.5
Cut stone Ashlar	15	25	20

13.6. Cost of Mortar Materials

13.6.1. The issue rates of cement on projects have been dealt with in Chapter 3 and their variations in cost explained.

13.6.2. The rate for manufacturing sand may be anything like Rs. 40/- to 60/- per CFC of solid rock or at 35% voids it would be Rs. 26/- to 39/- per CFC approximately for crushed sand.

13.6.3. Comparative table of the cost of sand used on various projects is given in table 13.6.3.

TABLE 13.6.3.

Comparative Statement of Rate of Sand per CFC on River Valley Projects

Sl. No.	Name of Project	Sand			Remarks
		Rate per CFC quarry site (Rs.)	Carriage charges	Issue rate at site of work	
1	2	3	4	5	6
1.	Matatila.	5.0	17.0	22.0	Contract rate. Lead not given.
2.	Gandhisagar.	25.1	11.2	36.3	Quarried under very difficult conditions. Lead 6 miles.
3.	Mayurakshi.	1.0*	7.0	8.0**	*For local river sand included in the contract rate. **Inclusive of Transport. Lead not given.
4.	Kakrapar.	10.0	2.4	12.4	Lead 1½ to ¾ mile (carried by donkey).
5.	Tungabhadra (Andh.).	8.1	16.9	25.0	Transport by railway wagon for 26 miles.
6.	-do- (Hyd.).		—	25.9	Average rate at Dam site with average lead 11.4 miles by Rly. wagon, storage & wastage etc. included.
7.	Lower Bhawani.	—	—	11.5	Inclusive of lead charges for 5½-6 miles.
8.	Malampuzha.	1.5	12.8	14.3	Quarry site lead charges 6 mile.
9.	Peechi.	4.0	17.4	21.4	Lead 5 miles. Contract rate.
10.	Perinchani.	3.3	11.7	14.0	Lead 5 miles. Contract rate.

13.6.4. Cost of grinding *surkhi* mortar as observed in Bhadra Project is given in Table 13.6.4. This does not include Tools and Plant charges.

TABLE 13.6.4.

Item	Place	
	Right Bank	Left Bank
1	2	3
Total qty. of mortar ground.	25,420 cyds.	9237 cyds.
Total power charges.	17373 9 0	7374 12 0
Total cost of stock articles issued.	18386 7 0	13362 7 0
Total labour charges.	15363 9 0	4506 8 0
Total water supply charges.	1243 4 0	235 2 0
Total Charges.	52366 13 0	25478 13 0
Remarks		
Rate per cyd.	2 0 11	2 12 2

$$\text{Average rate per cyd.} = \frac{2\text{-}0\text{-}11 + 2\text{-}12\text{-}2}{2} = 2\text{-}6\text{-}7$$

Rate per CFT = 0-1-5 without plant charges.

13.6.5. Comparative strength and cost of labour employed per CFC for different kinds of masonry on various projects is indicated in Table 13.6.5.

TABLE 13.6.5.

Sl. No.	Name of Project	Labour used per CFC of masonry				Cost	Remarks
		Skilled		Unskilled			
		No.	Avg.	No.	Avg.		
1	2	3	4	5	6	7	8
1.	Matatila.	2.5	3.7	7.6	1.4	19.6	Contract rate between RL 905 to RL 935.
2.	Gandhisagar.	1.0	4.0	6.4	2.3	18.5	Labour without lift charges.
3.	Mayurakshi.	—	—	—	—	28.0	Includes mixing, laying, curing, hire charges of machines.
4.	Kakrapar.	1.25	5.0	4	1.5	12.3	Include basic lead of 50 to 100 ft. & 5 to 10 ft. lift.

Table 13.6.5.—*contd.*

1	2	3	4	5	6	7	8
5.	Tungabhadra (Hyd.).	—	—	—	—	22.8	Break-up not given.
6.	Tungabhadra (Andh.)	2.0	3.0	9.2	1.0	15.1	No lift & lead included.
7.	Bhadra.	2.5	3.0	10.0	2.0	27.5	—do—
8.	Lower Bhawani.	—	—	—	—	16.3	Including curing charges, break-up not given.
9.	Malampuzha.	—	—	—	—	16.0	—do—
10.	Perinchani.	—	—	—	—	17.0	Labour contract includes for all lead and lift.

13.7. Lead And Lift

13.7.1. The cost of lead for materials has already been dealt with elsewhere and comparative cost of transport on various projects tabulated.

13.7.2. Hauling Mortar (Manual)

Extra labour involved on account of lifting mortar, water, etc. as the work goes up can be expressed in the form of multipliers.

TABLE 13.7.2.

Heights from ground upto	20′	....	1.0
	20′ to 40′	....	1.2
	40′ to 60′	....	1.3
	60′ to 80′	....	1.4
	80′ to 100′	....	1.5
	and so on.		

13.7.3. Hauling Stone

On large works the stone would be lifted up by crane. Data collected in respect of crane working in Tungabhadra is given below; the price of harbour crane stated to be Rs. 26,000/- is very low and this price has been assumed at Rs. 1,34,000—the present market price.

Depreciation charges per hour.

Cost of the crane including cost of repairs & renewals at 35% and railway transport charges. } Rs. 1,83,900

Depreciation per working hour : $\frac{183900}{15000}$ = Rs. 12.26

Erection charges

Total expenditure incurred on erection Rs. 9,000
Quantity of masonry likely to be tackled. 4000 CFC.

$\therefore$ Erection charges per unit $= \frac{9000}{4000}$ =Rs. 2.25.

Taking one week or 6 working days the labour charges are as below :—

(*i*)	Labour charges for rehandling materials.	Rs. 120.0
(*ii*)	Machine crew.	Rs. 50.75
(*iii*)	Depreciation charge 6 days, $47\frac{1}{2}$ hours: 47.5×12.26.	Rs. 582.5
(*iv*)	Cost of consumables	Rs.104.75
(*v*)	Erection charges at 2.25 per unit of masonry $96 \times 2.25 = 216$.	Rs. 216
		Rs. 1074.00

Working cost per day of 8 hours $= \frac{1074}{6}$

$= 179.0$

Working cost per CFC $= \frac{179.0}{16}$ = Rs. 11.2

In the non-spillway section the height over ground level to be tackled is about 80′. For lifts higher than this separate trestle arrangements or longer boom length would be required. Lift charges will vary according to the height and section of the dam. In Hirakud contract rate for lift charges is *Rs. 2.5 for every lift of 10ft. by manual labour.* For lift of 50′ and less the manual operation will be cheaper and for lift more than 50′ working by crane is advisable.

13.8. Rip rap

13.8.1. This item consists of a protective layer of stone laid on slopes and filled with spalls. The stones are bedded, one against the other. The slopes of soils where rip-rap is used shall not be steeper than their angles of repose. There are occasions when rip-rap is grouted with cement mortar as grout filler. The stone may comprise boulders collected from a stream bed or a natural quarry or alternatively it may be obtained by blasting from a stone quarry. The data collected from the projects is given in Table 13.8.1.

TABLE 13.8.1.

Sl. No.	Name of project	Unit	Stone	Carriage	Laying	Unit rate
1	2	3	4	5	6	7
1.	*Hirakud	100 cft.	3/-	9/7	3/7	20/14
2.	**Gangapur	,,	8/15	9/15	3/7	23/15
3.	†Malampuzha	,,	10/-	9/12	7/8	30/-
4.	††Lower Bhawani	,,	26/9	—	8/-	34/12
5.	§ Konar (DVC)	,,	18/-	12/10	6/9	37/3

* Rockfilling hand packed U/S & D/S toe.
** Also includes Rs. 1/7 as overhead charges.
† Also includes Rs. 2/12/- as miscellaneous charges.
†† Also includes -/13/- as incidental charges.
§ Original Rate.

CHAPTER 14

CONCRETE AND FORMWORK

14.1. Better Concrete

14.1.1. More recently, as the knowledge of 'Better Concrete' has widened, we find a growing tendency on the part of the Engineers to specify their concrete only in terms of strength. Such a move is decidedly in the right direction as this would lead to better quality and greater economy, in the use of cement and other ingredients of concrete. Many a treatise, explaining in detail the production of concrete of a predetermined strength from available materials, are now available.

14.1.2. For producing concrete of a particular strength, a somewhat more complicated concreting plant than the common mechanical mixer will be required, but the added expense of the same is found to usually off-sets by the more economical use of cement which becomes permissible. A testing laboratory is also an essential complement.

14.2. Proportioning of Ingredients

14.2.1. In the proportioning and measuring of the several ingredients entering into concrete, recourse should first be had to the specifications which would vary with the requirements of strength and use. (Table 14.2.1.). Representative proportions of concrete mixes by volume, the order being cement, sand and coarse aggregate are shown below for various uses of concrete in construction.

14.2.2. Conventional quantities of constituents for the above concrete mixes are tabulated in table 14.2.2.

14.3. Formwork

14.3.1. Proper design of forms will secure adequate safety with economy. The factors which affect design are :

1. The consistency of concrete.
2. The rate of filling between the forms.
3. The method of placing concrete.
4. The method of tamping or vibrating.
5. The depth of drop and distribution of steel in case of reinforced concrete.

TABLE 14.2.1.
Cement Concrete Mixes

Type	Quality	Proportion	Use
1	2	3	4
A	Rich	1:1½:3	R.C.C. special parts *e.g.* arches, copings, mouldings, stairs, columns, engine beds, piles etc., occasional use in P.C.C.
B	Standard	1:2:4	R.C.C. generally, roof slabs, lintels, beams, pillars, & P.C.C., in face work of dams and spillways, workshop floors etc.
C	Medium	1:2½:5	P.C.C. generally abutments, piers, thin retaining walls, strong foundations etc.
D	Lean	1:3:6	P.C.C. only used for good foundation, mass concrete work, backing to masonry works, spillways and thick training walls.
E	Weak	1:4:8	P.C.C. only used in ordinary foundations, mass concrete in compression, for hearting in dams of low height etc.
F	Cheap	1:5:10	P.C.C. as substitute for brick masonry retaining walls to earth, precast blocks for walls, in foundation to temporary and unimportant structures.
G	Poor	1:8:16	P.C.C. in bottoming to concrete foundation as a cheap backing, substituting poor soils in foundations, etc.

TABLE 14.2.2.
Conventional Material Constants for various Concrete Mixes

Proportion		Description of coarse materials	Cement cwts.	Sand dry FC	Coarse materials FC	Total aggregates FC
Cement, fine & coarse aggregates	Cement & aggregates					
1	2	3	4	5	6	7
1:1.5:3	1:4:5	Shingle	22.0	41	82	123
		Broken stone	21.3	43	86	129
1:2:4	1:6	Shingle	17.2	43	86	129
		Broken stone	18.1	45	90	135
1:2.5:5	1:7:5	Shingle	14.2	44	88	132
		Broken stone	14.9	46	92	133
1:3:6	1:9	Shingle	12.0	45	90	135
		Broken stone	12.65	47	94	141
1:4:8	1:12	Shingle	9.25	46	92	138
		Broken stone	9.70	48	97	145
1:5:10	1:15	Shingle	7.60	47	94	141
		Broken stone	8.05	50	100	150
1:8:16	1:24	Shingle	4.82	48	96	144
		Broken stone	5.11	51	102	153

NOTE: 1. Add after testing for bulkage of sand to quantities given in col. 5.
2. The aggregates for each mix should be proportioned after sieve analysis of their piles.
3. Variation of 5% on the above quantities may be the tolerance on the constants on account of the variation in densities of stone.
4. Waste in transit or handling on large works should not exceed 2½%.

14.3.2. The unit of measurement for forms should be actual area in square feet of the surface of the concrete in contact with the forms. The estimated materials should include materials for struts, posts, bracing, horizontal runners, wedges, bolts, wire, ties, oiling, cleaning and repairing but as also materials for staging and bridging.

14.3.3. Cost of forms is generally about 5 to 10% of the cost of concrete in dams construction while it is as high as 25-50% in case of structural parts of buildings. Where large quantities are involved, small saving in the unit cost amount to a large sum on the whole work which can be possible only if the forms are well planned for the job. Forms should preferably be manufactured in penal sections or other shapes which can be used several times, the greater number of uses obtainable with metal forms would generally result in a lower cost for use than with lumber. The cost of erection and stripping may be considered as uniform for each use, although there would be some saving in subsequent use. Small salvage value of formwork at the completion of the job may be ignored in calculating costs.

14.3.4. In order to resist the internal pressure resulting from the concrete some positive method of holding the forms in position is necessary. These methods will vary with the nature of work. In most cases, however, the ties used would be left inside the concrete and their cost should therefore be included in the unit cost.

14.4. Wooden Forms for Roof Slabs

14.4.1. Simple flat centering for concrete floors or roofs for 12′ height requires 10-20 cft. (15 F.C. average) timber per CFS. The quantity of timber required will increase in the height is increased mainly because of increase in the height of the vertical posts. Labour will also increase for greater heights. Analysis of rate for formwork for roof slabs is given below assuming 6 uses.

(*i*)	1½″ boards machine planned one side cages shot delivered on site (Rate includes wastage) C.F.S. 150/-	Rs. 150/-
(*ii*)	4 Nos. x 12.0 x 4″ x 4″ 5.3 F.C. posts for upright.	
	45 x 10′-0″ x 9″ x 3″ = 2.2 F.C. Tiles and braces.	
	15 F.C. @ 8/-	120/-
(*iii*)	Wedges and Cleats say 16 including top and bottom @ -/12/- each.	
(*iv*)	Clamps, dogiron, clamps strips 1/8 Cwt. @ Rs. 35/- per Cwt.	4/6
		286/6

	Preparing the initial shuttering.	31/4
		317/10
	Assume 6 uses of the above.	
	Therefore use and waste of materials per F.S.	Rs. 52/15
(v)	(2.0) Carpenter and (5.0) labourer repairing and fixing @ 5/- and 1/12 and stripping.	Rs. 18/12
(vi)	Add for oiling etc. to prevent concrete sticking to shuttering.	Rs. 2/-
	Total	Rs. 73/11
	Say :	Rs. 74/-
(vii)	Add for sundry materials.	Rs. 1/-
	Grand Total	Rs. 75/- per CFC

14.4.2. For different types of shuttering work the labour in erecting and striking per CFS would pay.

14.5. P.G.I. Covered Timber Planks over Timber Frames

14.5.1. The shuttering in panels of $6' \times 3'$ fixed to planks with wooden framework can, if well constructed be used at least eight times and on this basis the rate per C.F.S. is analysed below. The forms will have to be of a heavier construction than the dealt with in previous para 14.4.1. and would require 20—30 F.C. (25 F.C. average) lumber per hundred sq. ft. P.G.I. sheets 24 gauge in addition. The repairs, however, will not call for a great deal of new timber.

14.5.2. Analyses of (Primary) rates per C.F.S.

A. Formwork and planking.

1.	Planking 100 F.S. $\times 1\frac{1}{2}$ of hard wood = 12.5 @ 12/-	Rs. 150/-
2.	Cut sized for a panel of $6' \times 3'$	
	$6\frac{1}{4}' \times 2 \times 5'' = 1.4$ F.C.	
	$4 \times 3\frac{1}{4}'' \times 2\frac{1}{4}'' \times 5'' = .94$	
	2.34 per 18 F.S.	
	or $2.34 \times 100/18 = 13$ F.C. @ 8/-	Rs. 104/-
		Rs. 254/-

	Preparation of shuttering	Rs. 254/-
B.	G.I. Plain sheets (24 gauge)	Rs. 31/4
	100 F.S. = 106 lbs. @ 25/- per CWT.	Rs. 23/-
C.	5 lbs. Nails for fixing 100 s.ft. of Sheet @ -/8/- lb.	Rs. 2/8/-
		Rs. 310/12
	Assume 8 uses.	
	Cost per use and waste.	Rs. 38/14
D.	Steel for anchoring bolts and ties including labour 36 lbs. @ -/15/- per lb.	Rs. 12/4
E.	Share of bulli supports etc. 20% of Rs. 35/-	Rs. 7/-
F.	Erection and stripping	Rs. 18/12
G.	Miscellaneous.	Rs. 2/-
		Rs. 78/14/-

14.6. Manufacture of Heavier Type of Shuttering for use of Dams

14.6.1. Based on the data furnished by the Superintending Engineer, Konar, the cost of manufacturing steel shuttering and then using it eight times inclusive of labour in erecting and stripping is given below :—

Steel Shuttering-Analysis working with Crane

(a) Steel

	Quantity (tons)	Rate	Cost
(1) M.S. Plate 1/8″	57.0	Rs. 423/- per ton	24,111/-
(2) M.S. Plate 12 gauge	23.7	Rs. 423/- ,,	10,025/2/-
(3) M.S. Angle $2\frac{1}{2}'' \times 2\frac{1}{2}'' \times 4\frac{1}{2}''$.	52.81	Rs. 378/12 ,,	20,001/13/-
(4) M.S. Angle $2\frac{1}{2}'' \times 2'' \times \frac{1}{4}''$	16.00	Rs. 378/12 ,,	6,060/-/-
(5) M.S. Channel $4'' \times 2''$	67.35	Rs. 389/- ,,	26,199/8/-
(6) -do- $5'' \times 2\frac{1}{2}''$	35.5	Rs. 389/- ,,	13,908/8/-
(7) -do- $3'' \times 1\frac{1}{2}''$	20.25	Rs. 389/- ,,	7,875/4/-
(8) M.S. Flat $2\frac{1}{2}'' \times \frac{1}{4}''$	20.37	Rs. 378/- ,,	7,699/14/-
(9) 2″ dia. G.I. pipe	3.52	Rs. 1/7 per r. ft.	506/-
	Total:		1,16,287/11/-
	Say 1,16,300/-/-		

(b)	Fabrication charges 293 tons @ 300/- per ton	87,900/-/-
(c)	Transportation @ -/12/- per ton/mile, distance 1.5 miles, both way 3 miles.	2/4/-
	Loading, unloading and any other rehandling charges.	-/12/-
	Rate per ton	3/-/-

∴ 293 tons = 293 × 3 = Rs. 879/-

	Bolts and nuts 1/2"dia. 3-1/2" long. Total No. required for 8 sets. 33,000. Total weight-90 cwts. @ 70/-	6,300/-
(e)	Slotted pins and wedges 1/2" dia. $2\frac{1}{2}$" long -32000 @ 1/4/-each	40,000/-
(f)	Tube and nuts 5/5" dia. 27000 @ 25/-	67,500/-
(g)	Tube nuts 1" dia. 750 Nos. @ 22/-	16,500/-
		3,35,3791-
	Salvage at 20%	67,303/-
(h)	M.S. Rods 5/8" dia. & 1" dia. for achorage 250 tons at Rs.700/-	1,35,000/-
		4,03,303/-
	Total shuttering work to be done	11330 Units

$$\text{Cost per unit} = \frac{4,03,303}{11,330} = \text{Rs. } 35.5$$

Labour cost with Crane

Shuttering one sub-block 50'×40' ×5"
Total area = 900 sq. ft.
Shuttering time: 12 hours.

Machines.

	Cost of 35-Ton Crane	Rs. 2, 74,000
	life in hours	Rs. 16,000
(a)	∴ Depreciation per hour	Rs. 17.13
(b)	Major repairs and maintenance @ 60% of depreciation	Rs. 10.28
(c)	Labour—Operator & Maintenance	Rs. 2.256
	P.O.L. Charges.	Rs. 7.875
	Total use rate per hour	Rs. 37.54
	Taking crane use 10 Hrs. per 9 Units. Cost per unit.	Rs. 41.71

Labour

$\frac{1}{2}$ Foreman @ Rs. 300/- p.m.	Rs. 7.50
8 Khalasis at Rs. 2.0	Rs. 24.00
8 Male Mazdoors at 1.75	Rs. 21.00
3 Carpenters at Rs. 5/-	Rs. 22.50
	Rs. 75.00
Materials:—Linseed oil 1.5 Gals. at Rs. 8.5	Rs. 12.75
Total	Rs. 87.75
∴ Cost per unit	Rs. 9.75

1.	Capital cost of materials etc. per unit	Rs. 35.50
2.	Machineries (P.&H. Crane)	Rs. 41.71
3.	Labour and materials.	Rs. 9.75
		Rs. 86.96

Say Rs. 87/-per C.F.S.

14.7. Cost of Steel Formwork at Maithon

14.7.1. Cost of manufacturing heavy steel shuttering for Maithon Dam is Rs. 1,428/- per CFS shuttering and it is expected that these

will be used thirtyfour times with minor occasional repairs. Details of cost of manufacture are :—

Sl. No.	Item	Unit	Quantity	Rate	Amount
1.	Steel.				
	1.1 M.S. Plate of sizes.	Ton	0.52	527.0	274.04
	1.2 Structural sections.				
	1.2.1. Channels	,,	0.37	549.06	104.00
	1.2.2. Angles	,,	0.012	527.0	6.32
	1.2.3. Joints.	,,	0.039	527.0	20.56
	1.3 Other materials.	L.S.	—	—	183.38
	1.4 Bolts, nuts and edges etc.	Ton	0.32	856.25	276.00
2.	Fabrication		—	—	141.31
				Total	1105.60

3. Depreciation $= \frac{\text{Total Amount}}{\text{Number of uses}} = \frac{1105.60}{34}$

Use rate per panel of 78 sq. ft. = 32.5

Use rate per CFS = Rs. 42/-

14.7.2. Analysis for steel formwork per CFS of Concrete Surface

Sl. No.	Item	Unit	Quantity	Rate	Amount	Remarks.
1.	Depreciation of CFC steel shuttering.	CFC	—	—	42.0	
2.	Fixing and removing.	—	—	—	—	
	2.1 Cost of materials for anchorage. (Supporting pipes,, hooks, sal, ballah, cotton, waste etc.)	—	—	—	75.0	
	2.2 Crane charges.	—	—	—	43.0	
	2.3 Labour fixing and removal.	—	—	—	75.0	
	2.4 Linseed Oil etc.	—	—	—	0.1	
3.	Miscellaneous					
	3.1 Petty repairs	—	—	—	0.1	
	3.2 Transportation of materials from workshop to work site.	—	—	—	8.0	
	3.3 Clearing	—	—	—	—	Included in crane & labour charges.
	3.4. Add proportionate cost of :					
	Construction of carpentry workshops and fire hydrants.	—	—	—	3.8	
	Shop cost of wooden panels	—	—	—	10.8	
	Shop cost of drainage gallery panels.	—	—	—	13.4	
	Shop cost of operating gallery panels.	—	—	—	11.0	
	Total Primary cost				283.2	per CFS

14.8. Concreting Equipment

14.8.1. A complete concreting plant from crushing aggregate to laying concrete is a combination of several units and its output is linked up with that of the weakest unit. It is, therefore, essential that the entire plant should have a complete and continuous co-ordination among the units.

14.8.2. In planning a large crushing operation the economics of the related quarrying of the rock are directly involved and govern the selection of the crushing machinery. A careful study of the best combination for primary and secondary crushing may justify the installation of a larger crusher to receive larger pieces of rock from the quarry thus reducing secondary blasting and increasing the output.

14.8.3. A crushing and screening plant should be designed with some excess capacity over the expected continuous consumption, because the intermittent feed into the primary crusher may cause serious overloads on the belt conveyors and screens.

14.9. The Crushing Equipment

14.9.1. A modern stone and sand crushing plant usually consists of the following component parts: Primary Crusher, Scalping Screen, Secondary Crusher, Belt Conveyors, Sizing Screens, Sand Mills, Sand Screens, Classifiers or Washer, Storage Piles and Reclaiming system. The primary crusher of the jaw or gyratory type is installed with its top below the level of the quarry floor to permit direct loading from dumpers, wagons or railroad cars into a hopper above the crusher. A jaw crusher can generally take large pieces but has considerably less capacity than a gyratory crusher.

14.9.2. The secondary crusher for breaking down oversize rock is usually of the gyratory or cone type, which can be adjusted to smaller settings. In order to reduce the load on the secondary crusher, it is a standard practice to scalp out the acceptable sizes of crushed aggregate and deliver only the oversize to the secondary. Vibrating scalping screens for this class of service are very satisfactory.

14.9.3. Where the product from the primary crusher goes to a screening and secondary crushing operation the feed to the secondary crusher should be as constant as possible, and for this reason a surge pile beyond the primary crusher is desirable. From this pile a mechanical or vibrating feeder and belts deliver the crushed material at a uniform rate to succeeding operations.

14.9.4. The revolving screen is one of the simplest types and usually has relatively long life. However, it is more suitable for smaller installations or in connection with large natural gravel-pit operations.

Heavy duty single or multi-deck vibrating screens have now been developed for rock sizes upto 6 and 8 inches which, as a rule, are superior in operation, space requirements, in screening efficiency.

14.9.5. Sand may be produced either by direct grinding, attrition grinding, or by impact grinding. The most important elements to be met in a sand manufacturing process are sizes of the particles, gradation, shape and cleanliness. These factors dictate special precautions in the selection of sand making machinery.

14.10. Cost of Crushing and Screening

14.10.1. The data for crushing Basalt rock, obtained from Cost Accounting by HCC on Vaitarna Project, is given below:—

(1) C-1 Primary Crusher Jaw type Hadfield 200 tons capacity.

(2) Secondary Crusher C-2 Gyratory type 100 tons capacity.

	Ownership cost (Rs.)	Spares (Rs.)	Total (Rs.)	Life in working hrs. (thousand)	Depreciation & spares	Operating cost
1	2	3	4	5	6	7
Primary crusher with conveyors and civil engineering work for erection.	4,51,684	3,73,000	8,24,684	20	41.23	46.96
-do- secondary crusher with belts, screens, bins etc. kubit breakers.	12,10,193	7,20,000	19,30,193	18	107.23	68.06
Rod mills, marcy one of 12 ft. and second of 8 ft. length	2,32,699	90,000	3,22,699	18	17.92	17.85

14.10.2. The above crushing units were worked for 7000,10,000 and 12,000 hours to crush 1,66,44,000 cft. of solid rock into aggregates (coarse and fine sand). The total cost is :—

Equipment Use-rate per hour		Hours	Cost (Rs.)
1	2	3	4
1. Primary	41.23 46.96		
	88.19	7000	6,17,330
2. Secondary	107.23 68.06		
	175.29	10000	17,52,900
3. Rod Mills	17.92 17.85		
	35.77	12000	4,29,240
	Total Cost		27,99,470

∴ Cost of crushing % Cft. of Basalt solid rock into aggregates. of 6″×3″×1½″×¾″×3/8″ and below. $= \dfrac{27.99}{1.66} =$ Rs. 17.45

∴ Cost of crushing aggregates per CFC with 45% voids. $= \dfrac{17.45 \times 100}{140} =$ Rs. 12.5

NOTE: (a) The plant was used for crushing sand also otherwise cost of crushing would have been less.

(b) In the case of abrasive stones *viz.* Granite and sandstone, the above cost would increase up to 30%, according to the nature of the stone crusher.

14.10.3. The cost of crushing stone into coarse aggregates per CFC is indicated in table 14.10.3. All rates relate to stack measurements.

TABLE 14.10.3.

Sl. No.	Projects	Type of Rock.	Cost of crushing per CFC at Crusher (Stack with 40% voids).	Remarks
1	2	3	4	5
1.	Nangal	Shingle	10.0	Crushing round boulders.
2.	Maithon	Sandstone	24.5	
3.	Tilaiya	Sandstone	22.4	
4.	Hirakud	Granite	30.6	
5.	Vaitarna	Basalt	12.5	

14.11. WASHING AGGREGATES (MECHANICAL)

14.11.1. For primary washing of aggregates up to 6 or 8 inches in size and containing considerable clay, special scrubbers are used. These are large revolving cylinders with vanes and paddles which lift and tumble the gravel over itself in a bath of water. Another type for

washing stone and gravel is the log washer which operates as a screw washer does for sand. Further effective means of washing the aggregates as they go through a screening plant may be obtained by directing sprays or jets of water on the aggregate as it flows over the screens. An important point here is that high pressure is less effective in washing the aggregate as compared with greater volume at lower pressure. In some cases there is danger of washing out too many fines, from the 100 mesh screens, a size which is of considerable importance in making good concrete.

14.12. Transport from Stock-piles to Batching and Mixing Plant

14.12.1 For transporting materials from stock-piles to batching plant, use is made either of a continuous belt conveyor (or skip buckets operated by hoist cable). For this purpose at Maithon Dam (D.V.C.) reclamation tunnel has been laid under the full length of storage piles. Two belt conveyors have been installed. One is horizontal running under the stock-piles and other is inclined at 17.5 degrees to reach the bins in the batching plant. Working cost of the operation depends to a great extent on the working of the batching plant. If the latter cannot work continuously at optimum output, conveyor belts will have to remain idle intermittently, thereby increasing labour cost per unit of work.

14.12.2. Analysis of cost for transport from stock-piles to batching and mixing plant is given below :—

A.	**Depreciation**			
	Cost of discharge gates	Rs.	57,500	
	Cost conveyor belts and screens	Rs.	2,67,500	
	Cost of steel structure	Rs.	16,260	
		Rs.	3,41,260	
	Life in hours-10,000			
	∴ Depreciation per hour	Rs.	34.1	
B.	Repairs and Maintenance at 80% of depreciation.	Rs.	27.3	
C.	Energy Total H.P. 85 @ -/1/- per unit.	Rs.	4.1	Rs. 6.1
	(a) Electrical Materials	Rs.	1.0	
	(b) Sundry Materials.	Rs.	1.0	
D.	**Labour operation and Maintenance per hour**			
	3 operators (1 for gate and 2 for 2 belts) @ Rs. 4/8/-	Rs.	1.70	
	3 Helpers @ Rs. 3/- per day per shift	Rs.	1.12	
	3 Mazdoors @ Rs. 1/8/-	Rs.	0.56	
	1/2 Foreman @ Rs. 12/- per day per shift.	Rs.	0.75	
	2 Fitters @ Rs. 5/-	Rs.	1.25	
	1 Mechanic @ Rs. 5/-	Rs.	0.62	
		Rs.	6.00	

Total cost per hour = 34.1 + 27.3 + 6.1 + 6.0 = 73.5		
Output		32.40 CFC/hr.
∴ Cost per CFC		2.26
Add for erection, dismantling etc. as obtained at Maithon.		2.41
For dozing.		0.86
∴ Total per CFC	Rs.	5.53

14.13. Batching and Mixing

14.13.1. There have been radical improvements in batching and mixing equipment in recent years on account of the demand for better speed and control in manufacturing concrete. Automatic batching and recording has been introduced on some of the dams under construction.

14.13.2. The tilting mixer is the only type that can satisfactorily handle mixes containing cobbles. The mixer should be so located and arranged as to permit the operator to view the mixing operation during the processing rather than to judge the qualities of the mix after it is dumped. The mixing cycle of batch mixer of 2 cyds., and up, including charging the mixer mixing the concrete and discharging it, the maximum period required is 3 minutes.

14.13.3. Analysis of cost of batching and mixing operation is given below. The figures for the cost of plant is based on Maithon Project figures.

Operation of Batching and Mixing Plant (for cost of mixing)

1.	Cost of Batching Plant, with 3 mixers of 3 cyds. each at site	Rs.	7,45,900
2.	Life—16,000 hrs.		
3.	Depreciation per hr.	Rs.	46.6
4.	Repair and Maintenance @ 60%	Rs.	28.0
5.	Labour and Field maintenance per hr.	Rs.	6.7
6.	P.O.L. etc. per hr.		
	(a) Electric Energy	Rs.	2.5
	(b) Electric Material	Rs.	0.8
	(c) P.O.L.	Rs.	0.3
	(d) Sundries	Rs.	0.5
	Total cycle rate per hr.	Rs.	85.4
	Expected average output per 100 cyds. or 27 CFC per hour		
	∴ Use rate per CFC	Rs.	3.16
	Cost of water	Rs.	0.03
	Cost of erection and dismantling	Rs.	2.00
		Rs.	5.19

14.13.4. Analysis of cost of conveying mixed concrete from batching plant to pick up point by Diesel Locomotive and 6 cyds. buckets is given below :—

1.	Cost of Diesel Locomotive (B.H.P. 55)	Rs.	44,000
2.	Life —12000 hrs.		
3.	Depreciation per hour.	Rs.	3.67
4.	Repairs & Maintenance.	Rs.	3.67
5.	Labour operation & Field maintenance per hour. with POL.	Rs.	7.00
	Total cycle rate per hour.	Rs.	14.34

Output per hour 3 Locomotive on the site and 2 always working and giving an output of 27 CFC or 13.5 CFC per Loco.		
∴ Use rate per CFC	Rs.	1.31
Cost of Flat Wagon and Bucket per CFC	Rs.	1.00
Cost and maintenance of Trolley Line.	Rs.	0.35
	Rs.	2.66

Say, Rs. 2.66 per C.F.C.

14.13.5. Analysis of cost of Revolving Crane operation for lifting concrete bucket and placing is given below:—

1.	Cost of the 2 No. electric revolving crane 40 Ton capacity.	Rs.	1,73,500
2.	Life—12000 hours—each. 24000 hours.		
3.	Depreciation per hour.	Rs.	72.25
4.	Repairs and Maintenance per hour @ 60%.	Rs.	43.40
5.	Labour operation & Field maintenance per hour.	Rs.	7.09
6.	P.O.L. etc. per hour.		
	(a) Electric Energy.	Rs.	62.50
	(b) Electric Material.	Rs.	0.95
	(c) P.O.L.	Rs.	2.38
	Total Cycle rate per hour.	Rs.	188.57

Output per hour the same as batching plant.	Rs.	27.00 CFC
∴ Use rate per CFC	Rs.	7.00
Cost of erection and dismantling Crane.	Rs.	2.04
Cost of Steel Structure 1000 Tons, after allowing salvage value.	Rs.	6.60
Maintenance of Structure.	Rs.	0.11
Erection and dismantling of steel structure, 1000 Tons @ Rs. 300 per ton and distributed over the whole concrete 87000 CFC.	Rs.	3.45
Total Rate per CFC	Rs.	1,920

14.13.6. Analysis of cost of vibrating concrete per CFC is given below :—

1.	Cost 8 Nos. Electric Vibrators with frequency changers.	Rs.	40,000
		Rs.	40000
2.	Life— 10,000 hours.		
3.	Depreciation per hour.	Rs.	4.0
4.	Repairs and Maintenance per hour 100%.	Rs.	4.00
5.	Labour Operation & field maintenance per hour 2 Labourer per vibrator.	Rs.	1.50
6.	Cost of P.O.L. with electrical mixing and sundries.	Rs.	2.00
			11.50

Output per vibrator, on the assumption that 4 vibrators work continuously for 27.0 CFC per hour.

$\therefore$ Use Rate per CFC $\dfrac{11.50}{6.75} = 1.7$

14.14. ADMIXTURE

14.14.1. In U.S.A., since 1944, millions of cubic yards of air-entrained concrete have been placed in the construction of dams. The use of air etraining agents permitted an appreciable reduction in the cement content and the water/cement ratio. Besides special cements, which are generally more economical than portland cement have been lately used in the United States and laboratory investigations have indicated that the concrete containing these cements blended with portland cement compared favourably with concrete containing portland cement along.

14.14.2. As an element of cost of concrete the admixtures do not form an appreciable percentage and it is not considered necessary to discuss their price difference. However the cost incurred on their use has not been added to the cost of cement element in the analysis of mass concrete rates.

14.15. OVERALL RATES OF MASS CONCRETE

14.15.1. Overall rates of mass concrete (Table 14.15.1) inclusive (*i*) of all leads and lifts (*ii*) burden in addition to (*i*) and (*iii*) formwork in addition to (*ii*) are given. They vary from Rs. 228/- to Rs. 329/- per CFC.

TABLE 14.15.1.

Overall Rates of mass Concrete for CFC

Sl. No	Name of project	Cement quantity per CFC Cwt.	Quality of concrete in CFC	Cost in rupees (Lakhs)	Primary expense per CFC			Burden					Rate per CFC exclusive of form-work.	Form-work inclusive of on cost per CFC	Total rate per CFC inclusive of form-work
					Department	Contract	Contract	%on col. (6)	Amount	% on col. (7)	Amount.	Total col. (10)			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.	Maithon (Dam)														
	Class 'A' 300 lbs/Cyd.	9.9	64071	100	169	—	169	42	71	—	—	71	240	38	278
	Class 'B' 460 lbs/Cyd.	15.2	18862	36	197	—	197	42	83	—	—	83	280	38	318
2.	Panchet Hill (Dam)														
	Class 'A' 398 lbs/Cyd.	13.2	30267	48	186	—	186	40	74	—	—	74	260	42	302
	Class 'B' 506 lbs/Cyd.	16.7	29087	47	205	—	205	40	82	—	—	82	287	42	329
3.	Tilaiya (Dam)	14.0	38408	67	195	—	195	36	70	—	—	70	265	6	271
4.	Konar (Dam)	13.0	91800	224	—	244	244	—	—	9	22	22	266	4	270
5.	Hirakud (Dam) 1:3:6	14.53	185270	338	119	59	178	30	36	11	6	42	220	21	241
6.	Vaitarna (Dam)	12.0	191000	416	—	218	218	—	—	2	4	4	222	6	228

14.16. Formwork

14.16.1. Formwork for concrete are fabricated from lumber, plywood steel and aluminium, other separately or in continuation. If the form materials is not going to find its re-use, the forms would prove to be prohibitive in price. If, however, the forms are to be used 2-3 times then it will prove to be economical to manufacture them in timber only. Where they are required to be used many times it would pay to use durable materials. Special plywood for formwork is used when very smooth surface is required, and this is not necessary for concrete Dams, as they are costly.

A combined table for mass concrete inclusive & exclusive of formwork is given in Table 14.15.1.
14.16.1.

CHAPTER 15

ANALYSIS AND SCHEDULE OF RATES

15.1. Introductory

15.1.1. We have dealt with before the principal items of work and have reproduced the data which we had collected. We will give here their analysis of rates.

15.2. Basic Schedule of Wages

15.2.1. The labour rates given in table 15.2.1. will be applied to pricing the labour element in the analysis of rates. The rates for skilled and semi-skilled labour should be considered inclusive of all necessary tools which are normally carried by them.

TABLE 15.2.1.

Basic wages per day of 8 working hours

Item	Description of Labourers	Rate
	Un-skilled Labour	
1.	Bhisty including mussack	2.5
2.	Chokidar	1.75
3.	Mate (1 for 10 Mazdoors)	2.0
4.	Mazdoor Man [Grass Cutter, Stone Breaker or Packer Driver for donkeys (1 for 10) mules, camels (1 for 3 camels or mules or for bullocks)]	1.75
5.	Mazdoor Woman 18 years and above	1.25
6.	Mazdoor Boy (not less than 15 yrs. and under 18 years)	1.0
7.	Wadar Colly Male	2.5
8.	Wadar Cooly Female	1.5
9.	Wadar Cooly Boy	1.0
	Semi-killed & skilled	
10.	Blaster	4.5
11.	Crow Bar Man	3.5
12.	Fitter Cooly and Greaser	2.0
13.	Cleaner (Mech. Plant & Transport)	2.0

Table 15.2.1—contd.

14.	Fireman (Any static or mobile machinery)	3.0
15.	Glazier	3.0
16.	Hammerman	2.5
17.	Moulder (bricks or tiles)	2.5
18.	Pump Attendant	2.0
19.	Quarryman	3.5
20.	Roof Tiller or Thatcher	2.5
21.	Sawyer	3.5
22.	Well Sinker	4.0
23.	Lime Washer	2.0
24.	Carpenter Boy, Bellows Boy	2.0
25.	Mason (Stone) II	3.5
26.	Brick layer, Plasterer Floor II or Wall Tiler	4.0
27.	Carpenter II	4.0
28.	Fitter II	3.0
29.	Blacksmith II	3.5
30.	Mechanic II	5.0
31.	Painter II	3.0
32.	Plumber II	4.0
33.	Turner II	3.5
34.	Welder II	4.5
	Artisans & Technicians	
35.	Armature Winder	6.0
36.	Blacksmith I	5.0
37.	Boiler Attendant	3.5
38.	Brick-layers Plasterer I	5.0
39.	Carpenter I	5.0
40.	Driller (Well boring).	4.5
41.	Driver (Mechanical transport)	4.5
42.	Driver (Engine Static)	4.5
43.	Dresser	5.0
44.	Fitter I (Structural)	4.5
45.	Line-man.	4.5
46.	Mason (Stone) I	5.0
47.	Mechanic I	6.0
48.	Painter I	4.0
49.	Pattern Maker	5.5
50.	Plumber I	5.0
51.	Switchboard Attendant	2.5
52.	Turner I	5.0
53.	Welder I	6.0
54.	Wireman and Electrician	4.5
55.	Foreman Monthly Rated Labour 200—10—300—20—400	
56.	Operators (100—8—140—10—200)	

15.3. Basic Schedule of Prices

15.3.1. The rates given in table 15.3.1. have been applied to work out the material component of the rates.

TABLE 15.3.1.

Basic Schedule of Materials Rates

Sl. No.	Item with Description.			Unit	Rate	Remarks
1	2			3	4	5
	A. Cement & Steel					
1.	Portland Cement			Cwt.	5/-	Ex-Project Godown.
2.	Steel Rolled Sections			,,	20/-	-do-
3.	Mild Steel Bars			,,	24/-	-do-
4.	B.S.W. Binding Wire			,,	30/-	-do-
	B. Oils					
5.	Petrol			Gal.	2/12	-do-
6.	Diesel Oil			,,	1/8	-do-
7.	High Speed Diesel Oil			,,	1/2	-do-
8.	Mobil Oil			,,	4/-	-do-
9.	Lubricating Oil			,,	4/-	-do-
10.	Grease			Lb.	-/8/-	-do-
11.	Cotton Waste			,,	-/5/-	-do-
12.	Gear Oil			Gal.	5/-	-do
	C. Rubber Goods					
	Indian Prices	Ply.				
13.	6.0×16	6	Tractor Tyre	Each	101/15	
			Tractor Tube	,,	12/2	
14.	6.0×19	6	Tractor Tyre	,,	114/2	
			Tractor Tube.	,,	12/10	
15.	7.5×16	8	Trailer Tyre	,,	166/12	
			Trailer Tube	,,	25/-	
16.	7.5×16	8	Ribbed Earthmover Tyre	,,	186/10	
			Ribbed Earthmover Tube.	,,	17/2	
17.	7.5×18	6	Tractor Tyre	,,	143/5	
			Tractor Tube	,,	17/5	
18.	10.0×28	6	Tractor Tyre	,,	282/2	
			Tractor Tube	,,	42/5	
19.	11.0×28	6	Ground Grip Tyre	,,	402/8	
			Ground Grip Tube	,,	40/4	
20.	11.0×36	6	Ground Grip Tyre	,,	434/15	
			Ground Grip Tube	,,	62/-	

TABLE 15.3.1—contd.

1	2			3	4	5
21.	12.0×24	16	Rock Grip Tyre	Each	1037/4	
			Rock Grip Tube	,,	61/3	
22.	13.0×24	8	Grader Tyre	,,	781/7	
			Grader Tube	,,	70/7	
23.	14.0×24	20	Power Grip Tyre	,,	1406/-	
			Power Grip Tube	,,	114/8	
24.	18.0×24	16	Ground Grip Tyre	,,	2478/10	
			Ground Grip Tube	,,	207/7	
25.	18.0×24	24	Earthmover Tyre	,,	3261/2	
			Earthmover Tube	,,	207/7	
26.	18.0×24	24	Earthmover Tyre	,,	3979/14/-	
			Earthmover Tube	,,	207/7	
27.	18.0×25	16	Ground Grip Tyre	,,	2478/10	
			Ground Grip Tube	,,	207/7	
28.	18.0×25	20	Ground Grip Tyre	,,	3261/2	
			Ground Grip Tube	,,	207/7	
29.	18.0×25	24	Ground Grip Tyre	,,	3879/14	
			Ground Grip Tube	,,	207/7	
30.	21.0×25	20	Ground Grip Tyre	,,	3717/-	
			Ground Grip Tube	,,	256/8	
31.	21.0×25	20	Ground Grip Tyre	,,	3816/14	
			Ground Grip Tube	,,	256/8	
32.	21.0×25	24	Ground Grip Tyre	,,	4383/4	
			Ground Grip Tube	,,	256/8	
	U.K. Prices					
33.	8.2×20	12	Rock Grip Tyre	,,	417/7	
34.	9.0×20	12	Rock Grip Tyre	,,	479/14	
35.	9.0×24	12	Grader Tyre	,,	576/15	
36.	10.0×24	14	Rock Grip Tyre	,,	656/3	
37.	10.0×20	14	Rock Grip Tyre	,,	580/12	
38.	11.0×20	4	Rock Grip Tyre	,,	660/8	
39.	12.0×24	8	Earthmover Tyre	,,	543/12	
			Earthmover Tube	,,	49/13	
40.	14.0×24	8	Earthmover Tyre	,,	758/10	
			Earthmover Tube	,,	63/11	
41.	14.0×24	16	Earthmover Tyre	,,	1165/2	
42.	16.0×20	16	Earthmover Tyre	,,	1363/15	
			Earthmover Tube	,,	119/4	
43.	16.0×20	20	Earthmover Tyre	,,	1667/14	
			Earthmover Tube	,,	119/4	
44.	18.0×24	24	Rock Grip Tyre	,,	4030/11	
			Rock Grip Tube	,,	202/10	
45.	18.0×25	24	Rock Grip Tyre	,,	4030/11	
			Rock Grip Tube	,,	202/10	
46.	21.0×29	20	Ground Grip Tyre	,,	4065/5	
			Ground Grip Tube	,,	260/9	
47.	21.0×29	24	Ground Grip Tyre	,,	4620/7	
			Ground Grip Tube	,,	260/9	
48.	24.0×25	18	Ground Grip Tyre	,,	5095/13	
			Ground Grip Tube	,,	340/8	

TABLE 15.3.1—contd.

1	2			3	4	5
	U.S.A. Prices					
49.	9.0×24	10	Rib Tread Road-builder Tyre	Each	524/5	
			Rib Tread Road-builder tube	,,	40/4	
50.	10.0×24	10-	Road Builder Tyre	,,	619/11	
			Road Builder Tube	,,	33/2	
51.	12.0×28	6	Road Builder Tyre	,,	685/11	
			Road Builder Tube	,,	57/1	
52.	14.0×24	10	Road Builder Tyre	,,	923/13	
			Road Builder Tube	,,	63/11	
53.	14.0×32	16	Road Builder Tyre	,,	1743/6	
			Road Builder Tube	,,	78/4	
54.	16.0×24	16	Earthmover Tyre	,,	2398/8	
			Earthmover Tube	,,	200/5	
55.	24.0×25	24	Ground Grip Tyre	,,	6418/1	
			Ground Grip Tube	,,	340/8	
56.	24.0×25	30	Ground Grip Tyre	,,	7380/13	
			Ground Grip Tube	,,	340/8	
57.	24.0×29	24	Ground Grip Tyre	,,	8170/2	
			Ground Grip Tube	,,	534/6	
58.	24.0×29	36	Ground Grip Tyre	,,	10035/12	
			Ground Grip Tube	,,	534/3	
59.	27.0×33	30	Rock Grip Tyre	,,	13128/15	
			Rock Grip Tube	,,	910/9	
60.	27.0×33	36	Rock Grip Tyre	,,	15219/-	
			Rock Grip Tube	,,	910/9	
61.	27.0×33	30	Ground Grip Tyre	,,	12809/-	
			Ground Grip Tube	,,	910/9	
62.	30.0×33	40	Ground Grip Tyre	,,	18910/14	
			Ground Grip Tube	,,	1192/12	
			D. Explosives			
63.	Gelignite			Lb.	1/8	Ex-Project Godown.
64.	Fuse Wire or Coil			Coil	2/-	,,
65.	Detonators			100 Nos.	6/-	,,
			E. Principal Building Materials			
66.	Rubble Stone, inclusive of over burden removal and stocking.			CFC	18/-	At quarry with 40% Void.
67.	Rubbles Stone for Pitching			,,	12/-	,,
68.	Boulders			,,	5/-	At quarry.
69.	Gravel & Shingle			,,	8/-	-do-
70.	Stone Aggregate ½" to ¾"			,,	30/-	-do-
71.	Stone Aggregate 1" to 2"			,,	27/-	-do-

TABLE 15.3.1—contd.

1	2	3	4	5
72.	Stone Aggregate above 2″	CFC	25/-	At quarry
73.	Quarried Sand	,,	10/-	-do-
74.	Crushed Sand	,,	35/-	
75.	Stone Dust.	,,	35/-	
76.	Bricks 1st Class.	1000 Nos.	22/-	At kiln
77.	Bricks IInd Class.	,,	18/-	-do-
78.	Bricks IIIrd Class.	,,	15/-	-do-
79.	Brick Ballast of Sizes.	CFC	20/-	-do-
80.	Brick Bats.	,,	12/-	-do-
81.	Unslaked Lime	Md.	3/-	Site of work
82.	(a) Surkhi (Coarse)	CFC	30/-	-do-
	(b) Surkhi (Fine)	,,	75/-	-do-
83.	Scantlings Teak Wood (CP)	Cft.	12/-	-do-
84.	Scantling Salwood.	,,	6/-	-do-
85.	Planks Teak Wood.	,,	15/-	-do-
86.	Planks Salwood.	,,	8/-	-do-
87.	*Asbestos Cement Products*			
	(a) Plain Sheets	Sft.	-/7/-	
	(b) Corrugated Sheets	,,	-/8/9	
	(c) Corrugated Sheets Super 13.	,,	-/8/3	
	(d) Corrugated Sheets big 6.	,,	-/8/9	
	(e) Corrugated Sheets Trafford.	,,	-/8/6	
	(f) Ridges 3′ × 6¾″	Pair	6/3/-	
88.	*Ballies Sal*			
	(a) 3″ dia. 8′ to 10′ long.	Score	31/-	
	(b) 4″ dia. 12′ long.	,,	41/-	
	(c) 5″ dia. 12′ long.	,,	51/-	
	(d) 6″ dia. 12′ long.	,,	77/-	
	(e) 7″ dia. 12′ long.	,,	129/-	
	(f) 8″ dia. 12′ long.	,,	189/-	
89.	*Bitumen*			
	(a) For hot application (Asphalt, maxphalt, cutbacks, etc.)	Ton	412/-	
	(b) For cold application (Asphalt, maxphalt, cutbacks, etc.)	,,	397/-	
90.	Bhusa	Md.	3/-	

TABLE 15.3.1—contd.

1	2	3	4	5
91.	*Bamboos of Sizes*			
	(a) 1″ dia.	Score.	4/-	
	(b) 2″ dia.	,,	6/-	
	(c) 3″ dia.	,,	8/8	
92.	Baskets (Cane) 18″ internal dia.	Each	1/6	
93.	Board insulated	F.S.	6/-	
94.	Board laminated (Sitapur)	,,	3/8/-	
95.	Bleaching Powder	Lb.	1/8/-	
96.	Celotax sheeting.	F.S.	-/6/3	
97.	Coal Steam	Ton	41/-	
98.	Charcoal.	Md.	6/8/-	
99.	Coke.	,,	2/4/-	
100.	Coal Dust.	,,	1/8/-	
101.	Coal Tar	Gl.	1/4/-	

TABLE 15.3.2.

Trade Price of Mechanical Equipment

Sl.No.	Type of equipment	Size or capacity	Price in Rs.
1	2	3	4
1.	*Air Compressors*		
	(a) Portable (i) Diesel	210 C.F.M.	23,700
		315 C.F.M	34,800
		500 C.F.M.	52,700
	(b) Stationary (ii) Diesel	210 C.F.M.	22,850
		315 C.F.M.	33,700
		500 C.F.M.	51,700
		600 C.F.M.	73,500
	(iii) Electrica	315 C.F.M.	19.100
		500 C.F.M.	28,400
2.	Batching and Mixing Plant with 3 Nos. of 3 C.yd. Mixers.		7,26,200
3.	Bins, Cement (with accessories like indicators, valves etc.)	20″dia. 1244 Cft. capacity	64,000

TABLE 15.3.2—contd.

1	2	3	4
4.	Boilers: Vertical, Crosstube	10 H.P.	11,200
		12. H.P.	12,800
5.	Radial Cableway with hoist motors and other accessories with civil engineering works.	2100′ span 85′ height fixed headmast 10 Ton Gross load Skips and Slings.	7,00,000 each
6.	Core drilling machine (Diamond Core Drills)	Max. Depth.	
	(a) Power Operated.	500 ft.	15,600
		1000 ,,	25,500
		2000 ,,	33,000
	(b) Air operated.	500 ,,	18,000
7.	Concrete Buckets.	3 Cyd.	—
		$4\frac{1}{2}$,,	10,500
		6 ,,	15,000
8.	Cranes (a) Crawlers	17 Ton.	1,00,000
		25 ,,	1,34,000
		35 ,,	2,49,000
		50 ,,	3,14,000
	(b) Pneumatic Tyred	20 ,,	2,04,000
		30 ,,	2,12,000
	(c) Truck mounted	20 ,,	1,87,800
9.	Crusher (a) Jaw	150 to 200 Ton per/hr. 48″ × 36″	2,20,000
	(b) Gyratory	200 Ton per/hour.	—
10.	Engines, Diesel	75 H.P.	12,000
		115 H.P.	17,000
		190 H.P.	29,000
11.	Electric light Plant, Diesel Drive	12 K.W.	12,500
		20 K.W.	14,500
		25 K.W.	26,500
12.	Excavators (a) Diesel	$\frac{3}{4}$ Cyds.	1,10,000
	(i) Shovels	$1\frac{1}{2}$,,	2,11,000
		2 ,,	2,32,500
		$2\frac{1}{2}$,,	3,54,000
		$3\frac{1}{2}$,,	5,17,000
	(ii) Draglines	$\frac{3}{4}$,,	1,10,500
		$1\frac{1}{2}$,,	1,97,000
		2 ,,	3,10,000
		$2\frac{1}{2}$,,	3,22,000
		$3\frac{1}{2}$,,	4,58,000
	(b) Electrical		
	(i) Shovels	$\frac{3}{4}$,,	1,35,000
		$1\frac{1}{2}$,,	2,27,800
		$2\frac{1}{2}$,,	3,24,500
		$3\frac{1}{2}$,,	5,64,000
	(ii) Draglines	$\frac{3}{4}$,,	1,39,000
		$1\frac{1}{2}$ to 2 ,,	2,19,000
		2 to $2\frac{1}{2}$,,	2,58,600

TABLE 15.3.2—contd.

1	2	3	4
13.	Grader	75 H.P.	84,000
		104 H.P.	87,000
14.	Hoists (a) Air Hoist (Total Lift 15′)	10 Cwt.	2.900
		20 ,,	3,000
	(b) Chain Hoist	9 Cwt.	1,560
	(c) Electric Hoist	1 Ton	6,850
15.	Loaders	9 B.V.	2,13,000
		10 B.V.	2,40,000
16.	Locomotives, Diesel	55 B.H.P.	40,000
17.	Mixers, Concrete.	10/7 Cft.	7,300
		1½ Cyd.	27,500
		2 ,,	67,000
18.	Pile Driver (Complete plant with all steel frame mounted on swivelling jucking rail, wheels, hammer, double-hammer, drum steam and Boiler with 50 ft. and single acting (S.A.) Hammers.	2 Ton	91,500
19.	Pile Hammers (Single acting complete with valves)	2 Ton.	12,200
		2½ Ton.	13.600
		3 Ton.	16,000
20.	Pneumatic Tools		
	(a) Drifters	3½ Bore	4,500
	(b) Jack Hammers	37 Lbs.	680
		48 ,,	780
		55 ,,	920
	(c) Pumps-Sum	(a) 133 G.P.M. at 10′ Total head and 21 G.P.M. at 100′ total head.	980
		(b) 189 G.P.M. 5′ Total head 300 P.M. at 60′ total head	1,130
	(d) Vibrators	2½ Casing	575
	(e) Wagon drills	Light duty	10,000
		Heavy duty	17,000
21	Pumps		
	(a) Concrete Pump, Diesel	10 Yds.	42,900
		24 ,,	48,500
	(b) Cement Grout Pump	—	—
	(c) Cement Pump	20 to 22 Tons per hr. 76′/distance	52,500
	(d) Centrifugal Pumps (maximum head 150′)	2,200 G.P.H.	2,000
		3,000 G.P.H.	3,400
22.	Rollers		
	(a) Sheepsfoot	Single drum	3,900
		Twin drum	6,200
	(b) Road rollers (Diesel)	6 to 8 Tons	311,00
		8 to 10 ,,	38,500
23.	Blast Out-fit (with dust collector)	44″×40″	38,500
24.	Scrappers	10/13 Cyds.	1,54,000
	(a) Motorised	11 Cyds.	43.900
	(b) Towed	16 Cyds.	55.000

TABLE 15.3.2—concld.

1	2	3	4
25.	Screens-vibrating		
	(a) Single Deck	48″×96″	(a) 7,700
	(b) Double Deck		(b) 9,200
		48″×120″	(a) 8,250
			(b) 10,000
		60″×120″	(a) 8,850
			(b) 12,400
		60″×160″	(a) 12,100
			(b) 12,300
26.	Tractors	90 B.H.P.	80,500
	(a) Crawlers	130 B.H.P.	1,08,100
		25 B.H.P.	13,500
		45 B.H.P.	18,750
		55 B.H.P.	20,000
27.	Trucks—Dumpers		
	(a) Bottom Dump	13 Cyds.	1,49,500
		17 ,,	1,97,600
	(b) Rear Dump	6.6 Cyds.	1,10,000
		10 Tons	
		9.7 Cyds.	1,35,000
		15 Tons	
		14.8 Cyds.	2,04,000
		22 Tons.	
28.	Well-drilling Machine	From 6″ dia. holes-750′ 8″-500′ to 16″—100′-	
29.	Welding Machine	(a) Continuous output of 200A.	12,000
	(Diesel Engine Drive Welding Set)	(b) -do- 300A	13,000

NOTES : 1. The prices listed are approximate.
2. The prices for F.O.R. Indian Port.
3. They are subject to variation, trade discount and the like.

15.4. Use Rates and Outputs of Machines

15.4.1. Table 15.4.1. gives the hourly use rates of mechanical equipmetn.

15.4.2. Outputs of various machines have been dealt with in Chapter 6.

TABLE 15.4.1.

Hourly Use Rate of Mechanical Equipment

Sl.No.	Equipment	Hourly Use Rates in Rs.
1	2	3
1.	*Air Compressors*	
	(a) 210 C.F.M. Diesel, Portable	10.5
	(b) 315 C.F.M. Diesel, Portable	14.0
	(c) 500 C.F.M. Diesel, Portable	20.0
	(d) 500 C.F.M. Electrical, Stationary	16.5
2.	*Belt Loader*	
	18 B.V. Belt Loader	55.0
3.	*Dump Truck*	
	(a) 9.7 Cyd. 15 Tons Rear Dump	34.0
	(b) 14.8 Cyd. 22 Tons Rear Dump	52.0
	(c) 13 Cyd. Struck Bottom Dump	37.0
	(d) 17 Cyd. Struck Bottom Dump	47.0
4.	*Excavators*	
	(a) Shovel	
	(*i*) ¾ Cyd. Shovel	31.0
	(*ii*) 1½ ,, ,,	50.0
	(*iii*) 2½ ,, ,,	64.0
	(*iv*) 3½ ,, ,,	89.0
	(*b*) *Draglines*	
	(*i*) ¾ Cyd. Dragline	29.0
	(*ii*) 1½ ,, ,,	43.0
	(*iii*) 2½ ,, ,,	55.0
	(*iv*) 3½ ,, ,,	74.0
5.	*Scrappers*	
	(a) 10/12.5 Cyd. Drawn Scrapper	14.0
	(b) 15/20 ,, -do-	20.0
	(c) 10/13 ,, Motorised	43.0
	(d) 15/20 ,, -do-	56.0
6.	*Tractors*	
	(a) 81 H.P. Crawler Tractor	25.0
	(b) 130 H.P. Crawler Tractor	29.0
	(c) 81 H.P. Tractor Dozer	28.0
	(d) 130 H.P. Tractor Dozer	32.0
	(e) D-4 Tractor with Sheepsfoot Roller	15.15
7.	*Motor Grader*	
	115 H.P.	25.0

15.5. Labour and Material Constants

Labour and material constants for various items are given below:—

15.5.1. Farthwork by Manual Labour

TABLE 7.2.2.

Sl. No.	Type of Soil	Range of labour effort per CFC	Range of rates per CFC
1	2	3	4
1.	Sand and silt	0.25—0.4	0.45—0.72
2.	Top soil	0.4 —0.6	0.72—1.08
3.	Common earth	0.5 —0.8	0.9 —1.44
4.	Clay, light	0.7 —1.0	1.26 —1.8
5.	Clay, heavy	0.85—1.2	1.5 — 2.2
6.	Soft rock	1.4 —2.5	2.5 — 4.5

TABLE 7.3.1.

Labour Effort Constants in Man-days and Rates in rupees for removal of Spoil per CFC

Sl. No.	Horizontal distance betwεen (CFR units)	Removal of Spoil				Remarks
		Soil		Rock		
		Labour	Rate	Labour	Rate	
1	2	3	4	5	6	7
1.	0.25	0.13	0.17	0.17	0.22	It is assumed that a person carrying soil travels 200 ft. per minute & it takes 0.06 minute to unload a basket. For carrying rock the speed be reduced to 150 ft. per minute.
2.	0.50	0.23	0.30	0.30	0.39	
3.	1.0	0.43	0.58	0.59	0.77	
4.	1.5	0.63	0.82	0.86	1.12	
5.	2.0	0.83	1.08	1.14	1.48	
6.	2.5	1.03	1.34	1.43	1.86	

TABLE 7.3.3.

Rates of Earthwork (CFC) by Manual Labour

Sl. No.	Type of Soil	Range of labour effort (man-days)	Rates at average wages		
			Rs. 1.5	Rs. 1.8	Rs. 2.1
1	2	3	4	5	6
1.	Sand & silt	0.48-0.63	0.72-0.94	0.86-1.13	1.01-1.32
2.	Top soil	0.63-0.83	0.94-1.35	1.13-1.49	1.32-1.74
3.	Common earth	0.73-1.03	1.09-1.54	1.31-1.85	1.53-2.16
4.	Clay, light.	0.93-1.36	1.4-2.04	1.63-2.45	1.95-2.85
5.	Clay, heavy	1.06-1.53	1.62-2.29	1.95-2.76	2.27-3.21
6.	Soft rock	1.70-2.3	2.55-4.20	3.06-5.04	3.57-5.88

TABLE 7.3.4. (*i*)

Rates of Earthwork (CFC) by Manual Labour

Sl. No.	Type of Soil	Labour effort in man-days for digging and disposal of spoil for leads					
		.25	.5	1.0	1.5	2.0	2.5
1	2	3	4	5	6	7	8
1.	Sand & silt	0.38-0.53	0.48-0.63	0.68-0.83	0.88-1.03	1.08-1.23	1.28-1.43
2.	Top soil	0.53-0.73	0.63-0.83	0.83-1.03	1.03-1.23	1.23-1.43	1.43-1.63
3.	Common earth	0.63-0.93	0.73-1.03	0.93-1.23	1.13-1.43	1.33-1.63	1.53-1.83
4.	Clay, light	0.93-1.33	1.03-1.53	1.23-1.63	1.43-1.83	1.63-2.03	1.83-2.23
5.	Clay, heavy	1.13-1.63	1.23-1.73	1.43-1.93	1.63-2.13	1.83-2.33	2.03-2.53
6.	Soft rock	1.57-2.67	1.70-2.80	1.90-3.09	2.26-3.36	2.54-3.64	2.83-3.93

15.5.2. Transport

TABLE 8.2.1.

Weights of Local Construction Materials

Sl. No.	Nature of materials	Weights		Remarks
		Lbs. per FC	Tons per CFC	
1	2	3	4	5
1.	Quarried or crushed stone			
	(i) Limestone	80	3.57	The data given is based on 45% voids.
	(ii) Granite	92	4.11	
	(iii) Basalt	95	4.24	
2.	Bankrum shingle containing sand.	100	4.46	
3.	Gravel or shingle without sand	94	4.20	
4.	Clean pits & dry	90	4.02	
5.	Slaked lime powder	60	2.68	

15.5.3. Drilling and Quarrying

TABLE 9.2.1.

Drilling Performance (feet per hour)

Diameter of hole (inches)	Class of rock	Rock Drills		Core Drills	
		Jack-hammer	Wagon drill	Diamond drill	Shot drill
$1\frac{1}{4}$ (Core 1-1/8)	Soft to medium	10 to 12	25 to 35	3 to 7	
$2\frac{3}{5}$ (Core 1-5/8)	Soft to medium	5 to 10	20 to 25	2 to 4	
$2\frac{3}{8}$ (Core 1-1/5)	Hard				
3 (Core 2-1/8)	Soft to medium hard	3 to 8	15 to 25		
4 (Core 3)	Soft to medium hard		5 to 10 3 to 5		1 to 2
6 or $5\frac{1}{2}$ (Core 4-3/4)	Soft to medium hard		3 to 6 1 to 3		$\frac{3}{4}$ to $2\frac{1}{2}$ $\frac{1}{2}$ to $\frac{3}{4}$
12	Soft to medium hard		1 to 4		
36	Soft to medium hard				$\frac{1}{2}$ to 1 $\frac{1}{4}$ to $\frac{1}{2}$

TABLE 9.5.1.

Air Consumption of Punematic Tools

Sl. No.	Tool	CFM
1.	Drills rock jackhammers	
	30 lb. Weight	60
	45 ,,	85
	55 ,,	95
	80 ,,	125
	Augurs	85
2.	Drifters (Wagon drills)	
	85 lbs. Weight	125
	100 -do-	155
	140 -do-	200
3.	Hoists 500-1000 lbs. capacity 1.5 (consumption/ft. of lift)	
	2000 lb.	2.0
	3000 lb.	3.0
	4000 lb.	6.5
	5000 lb.	8.5
4.	Pavement Breakers	
	30 lbs. Weight	45
	55 -do-	50
	85 -do-	75
5.	Sump Pumps	
	Upto 100 ft. head	65
	Upto 185 ft. head	115
6.	Tampers-backfill	
	25 lbs. Weight	30
	32 lbs. -do-	35
7.	Trench diggers	
	25 lbs. Weight	35
	45 lbs. -do-	45

TABLE 9.6.2.

Analysis of Rates for Blasting Rock

1.	Gelatine 2.25 lbs. at Rs. 1.5 per lb.	3.38
2.	Detonators 4 Nos. at Rs. 6 per 100 Nos.	0.24
3.	*Labour*	
	3.1. Blaster 0.01 at Rs. 4.5 each	0.05
	3.2 helper or quarry man 0.02 at 3.5 each	0.70
		4.37
	Say, Rs.	4.5

15.5.4. Brickwork and Lining of Canals

TABLE 11.1.3.

Number of Bricks per CFC (exclusive of wastage)

Size of Brick	Thickness of joints		
	1/4″	5/16″	3/8″
9″ ×4-3/8″×2-11/16″ (Standard Brick)	1350	1200	1270
10/″ ×5″ ×2¼″	1040	1000	975

TABLE 11.2.2.

Quantity of Mortar used in a 1½ Thick Wall

Thickness of joints in inches	1/4″	5/16″	3/8″
	Cft.	Cft.	Cft.
Mortar per 1000 bricks	14	17	21
Mortar per CFC of brickwork	19	22	25

TABLE 11.2.5.

Quantities of various Ingredients of Mortar

Type of Mix	Ratio	Ingredients per FC				Labour mixing/FC (man-day.)
		Cement Cwt.	Lime Mds.	Sand FC	Surkhi FC	
LSM	1:2	—	0.27	1.0	—	0.012
	1:3	—	0.20	1.1	—	,,
	1:4	—	0.15	1.2	—	,,
CLM	1:1:4	0.21	0.14	1.0	—	0.015
	1:1:6	0.15	0.10	1.1	—	,,
	1:1:8	0.12	0.08	1.2	—	,,
CK	1:2	0.49	—	1.0	—	0.012
	1:3	0.29	—	1.1	—	,,
	1:4	0.29	—	1.2	—	,,
	1:5	0.21	—	1.3	—	,,
RCM	4:1:10	0.34	—	1.0	0.08	0.02
	4:1:15	0.25	—	1.1	0.06	,,
	4:1:20	0.19	—	1.2	0.05	,,

TABLE 11.3.2.

Plant and Labour required for CFC Mortar

Nature of mortar	Plant hour per CFC	Labour days per CFC
Lime, Sand (LSM)	4	1.00
Cement, Lime, Sand (CLM)	4.5	1.25
Cement, Sand (CM)	5	1.33
Cement, Surkhi, Sand (RCM)	6.0	1.50
Lime, Ashes or Surkhi	6.5	1.66

TABLE 11.4.1.

Approximate Rate or laying Bricks for Heights not exceeding 10′ (*Common Brickwork*)

Sl. No.	Thickness of walls—	No. of bricks laid with struck joints (per day per mason)					
		On one face			On two faces		
		From	To	Average	From	To	Average
	1	2	3	4	5	6	7
1.	½ Brick Wall.	300	500	400	250	400	325
2.	1¼ -do-	400	600	500	300	500	400
3.	1½ -do-	500	800	650	400	600	500
4.	2 -do-	600	1000	800	500	700	600
5.	2½ -do-	700	1200	950	550	750	650
6.	3 -do-	800	1400	1100	600	800	700

11.4.2. The amount of work done per day by a helper can be any one of the following to his credit.

1. Mix 100 to 120 F.C. of mortar.
2. Deliver 3000 to 5000 bricks to a distance of 50′.
3. Deliver mortar 150 to 250 F.C.
4. Two good helpers can handle 100 to 200 ton of pole staging.

15.5.5. Stone Masonry

Recommended quantities of mortar per CFC of masonry are given in table below :—

TABLE 13.5.2.

Mortar per CFC Masonry (*UCR*)

Kind of Masonry	Mortar in (CFC) per CFC Masonry		
	From	To	Average
1	2	3	4
Rubble.	40	50	45
Squared-stone Coarsed.	25	40	32.5
Cut-stone Ashlar.	15	25	20

13.7.2. *Hauling Mortar (Manual)*

Extra labour involved on account of lifting mortar water etc., as the work goes up can be expressed in the form of multipliers.

TABLE 13.7.2.

Heights from ground upto	20′	.... 1.0
	20 to 40	.... 1.2
	40 to 60	.... 1.3
	60 to 80	.... 1.4
	80 to100	.... 1.5
	and so on.	

15.5.6. Concrete

Convention of material constants for various concrete mixes are given below in Table 14.2.2.

TABLE 14.2.2.

Proportion cement, fine & coarse aggregates	Proportion cement & aggregates	Description of coarse materials	Cement Cwt.	Sundry FC	Coarse materials FC	Total aggre-gates FC
1:1.5:3	1:4:5	Shingle	22.0	·41	82	123
		Broken Stone	21.3	43	86	129
1:2:4	1:6	Shingle	17.2	43	86	129
		Broken Stone	18.2	45	90	135
1:2.5:5	1:7:5	Shingle	14.2	44	88	132
		Broken Stone	14.9	46	92	133
1:3:6	1:9	Shingle	12.0	45	90	125
		Broken Stone	12.65	47	94	141
1:4:8	1:12	Shingle	9.25	46	92	138
		Broken Stone	9.70	48	97	145
1:5:10	1:15	Shingle	7.60	47	94	141
		Broken Stone	8.05	50	100	150
1:8:16	1:24	Shingle	4.82	48	96	144
		Broken Stone	5.11	51	102	153

NOTES: 1. Add after testing for bulkage of sand to quantities given in Col. 5.

2. The aggregates for each mix should be proportioned after sieve analysis of their piles.

3. Variation 5% on the above quantities may be tolerance on the constants on account of the variation in densities of stone.

4. Waste in transit or handling on large works should not exceed 2½%.

15.6. Rates for Preliminary Work

15.6.1. The rates of expenditure on preliminary surveys as stipulated by the Survey of India are given below for guidance :—

Air mapping	Rs. -/10/8	per acre.
Detailed ground contour survey.	Rs. 1/10/-	-do-
Land use Survey and Planning.	Rs. -/12/6/	-do.-
Forest Survey.	Rs. -/10/6	-do-
Upland Irrigation survey including drilling, test pits, canal layouts, dam design.	Rs. 1/8 /-	-do-

15.6.2. Analysis and schedule of rates for site clearance by Manual Labour are given in Table 15.6.2.

TABLE 15.6.2.

Item	Unit	No. of labour	Rate Rs.	Per	Amount Rs.	Rate per kcre Rs.
1	2	3	4	5	6	7
Clearing scrub jungle without rooting out.	MFS	1	1.8	Each	1.8	78.4
Clearing scrub jungle including rooting out.	MFS	2	1.8	Each	3.6	156.8
Clearing light jungle without rooting out.	MFS	2	1.8	Each	3.6	156.8
Clearing light jungle including rooting out.	MFS	4	1.8	Each	7.2	313.6
Clearing heavy jungle without rooting out.	MFS	4	1.8	Each	7.2	313.6
Clearing heavy jungle including rooting out.	MFS	8	1.8	Each	14.4	627.2
Clearing thick & thorny jungle including rooting out	MFS	9	1.8	Each	16.2	705.6

Note : Labour Constant relates to a particular project.
No yardstick can be laid down for general application.

15.6.3. Analysis and schedule of rates for site clearance and reclamation work by machines are given below :—

TABLE 15.6.3.

Sl. No.	Details of Expenditure	Tractor (84 H.P.) 1950-52 Cost per hour Rs.	Tractor (190 H.P.) 1950-52 Cost per hour Rs.	Tractor (130 H.P.) 1950-52 Cost per hour Rs.
1	2	3	4	5
1.	Salaries and Wages	7.2	6.3	4.8
2.	Stores consumed	4.3	3.6	3.4
3.	P.O.L. consumed	8.6	8.7	6.1
4.	Contingencies	0.4	0.5	0.2
5.	Transportation charges	2.6	3.8	1.0
6.	Depreciation	14.9	13.7	11.7
7.	Maintenance charges	0.4	0.4	0.4
8.	Repairs and renewals reserves	14.1	12.8	11.0
9.	Rehabilitation charges	0.2	0.2	0.2
10.	Preliminary expenses	0.8	0.8	0.8
11.	Interest on Capital	4.3	4.3	4.3
12.	Audit Charges	0.1	0.1	0.1
13.	Direction Charges	1.6	1.2	1.0
14.	Deficiency in Workshop	0.4	0.4	0.4
		59.9	56.8	45.4
	Total Hour Ploughed	52,230	18,979	22,520
	Total Average	51,809	21,311	22,119
	Average per hour	0.99	1.1	1.0
	Cost per Acre (Rs.)	60.5	49.0	45.4

NOTE : The data given above is obtained from the reclamation work executed by the Central Tractor Organization in Bundelkhand (U.P.).

15.7. Transport Rates

15.7.1. Cost of transport of materials by petrol trucks is given below :—

TABLE 8.4.3.

Cost of transport by petrol trucks (5 tons)

Lead in miles	Cost of variable (a+b+c=Rs. 0·723 per mile) per round trip	Cost of constants (d+e+f= Rs. 20.75) per day of 8 hrs.	No. of trips per day	Cost of Constants (Rs.20.75) per trip. Col.3/4	Total Cost per mile round trip Col. 2+5	Capacity per trip	Primary Rate per CFC
1	2	3	4	5	6	7	8
			Rubble Stone				
1.	1.446	20.75	8	2.594	4.040	CFC	4.0
2.	2.892	20.75	8	2.594	5.486	CFC	5.5
3.	4.338	20.75	7	2.964	7.302	CFC	7.3
			Bricks				
							Primary rate per 1000 Nos.
1	1.446	20.75	8	2.594	4.040	1250 No.	3.2
2	2.892	20.75	8	2.594	5.486	1250 No.	4.4
3	4.338	20.75	7	2.964	7.302	1250 No.	5.8
			Fine and Coarse Aggregates				
							Primary rate per CFC
1	1.446	20.75	7	2.964	4.410	CFC	4.4
2	2.892	20.75	7	2.964	5.856	CFC	5.9
3	4.338	20.75	6	3.458	7.796	CFC	7.8

NOTES : 1. Rates include cost of labour for loading and unloading.
2. Rates are applicable to type 'A' roads-Cement, Oil bound, and good metalled roads.
3. Add to the above 15, 20 and 30% for class B, C and D type roads respectively.

TYPE : B. Gravel, Kankar and murum roads.
C. Rough metal Roads.
D. Soft Roads.

15.7.2. Cost of transport of materials by diesel trucks (5 tons) is given below :—

TABLE 8.4.5.

Lead in miles	Cost of variables (a+b+c= Rs.0.54) per mile per round trip.	Cost of constants (d+e+f= Rs.20.75) per day of 8 hrs.	Number of trips per day	Cost of constants (Rs. 20.75) per trip (Col. 3/4)	Total cost per mile round trip (Col. 2+5)	Capacity per trip	Primary rate per CFC. Rs.
1	2	3	4	5	6	7	8
			Rubble Stone				
1	1.096	20.75	8	2.594	3.690	CFC	3.7
2	2.192	20.75	8	2.594	4.786	CFC	4.8
3	3.288	20.75	7	2.964	6.252	CFC	6.3
			Bricks				
						Nos.	Primary rate per 100 Nos.
1	1.096	20.75	8	2.594	3.690	1250	3.0
2	2.192	20.75	8	2.594	4.786	1250	9.8
3	3.288	20.75	7	2.964	6.252	1250	5.0
			Fine & Coarse Aggregates				
							Primary rate per CFC
1	1.096	20.75	7	2.964	4.060	CFC	4.1
2	2.192	20.75	7	2.964	5.156	CFC	5.2
3	3.288	20.75	6	3.458	6.746	CFC	6.7

NOTES : 1. Rates include cost of labour for loading & unloading.
2. Rates are applicable to type 'A' roads-cemented, oil bound and good metalled roads.
3. Add to the above 15, 20, and 30 per cent for Class B, C & D type roads respectively.

TYPE : B. Gravel, *kankar* and murum roads.
C. Rough metal Road.
D. Soft Roads.

15.8. Earthwork by Machines

15.8.1. Cost of mucking rock by $2\frac{1}{2}$ cyds. shovel and 9.7 cyds. dumper is given below :—

TABLE 6.11.4. (iii)

Rate per CFC of Blasted Rock excavated and loaded by $2\frac{1}{2}$ cyds. Shovel and hauled by Rear Dumper (9.7 cyds.)

Load one way haul in feet	Equipment Cost (Rs.)	Output CFC	Rate per CFC (Rs.)
1000	160	34	4.7
2000	194	34	5.7
3000	228	34	6.7
5000	296	34	8.7
6000	364	34	10.7
8000	432	34	12.7

15.8.2. Earthwork rates by shovels per CFC are tabulated below :—

TABLE 6.11.6.

Soils	Lead one way haul in feet					
	1000	2000	3000	5000	6000	8000
Moist loam or light Sandy clay.	2.75	2.75	3.5	4.5	5.6	6
Sand and Gravel	2.75	2.75	3.75	5	5.6	6
Good common earth	3	3	3.75	5	6	6.5
Clay, hard and tough	3.5	3.5	4.5	5.75	7	7.5
Clay, wet and sticky	4.5	4.5	5.75	7.5	9	10

15.8.3. Rates of Earthwork by Tractor-Scrappers per CFC are tabulated below :—

TABLE 6.11.10.

Sl. No.	Soils.	Lead one way haul in feet					
		500	600	800	1000	1200C.	1500
1	2	3	4	5	6	7	8
1.	Light loam or crumbly silt	1.84	1.96	2.09	2.24	2.0	2.9
2.	Sand and Gravel	2.24	2.33	2.46	2.60	2.41	3.32
3.	Good common earth	1.93	2.06	2.20	2.36	2.07	2.99
4.	Clay, hard and tough	2.35	3.53	3.68	2.86	2.61	3.58
5.	Murum	2.26	2.37	2.50	2.64	2.95	3.36
6.	Hard murum	2.50	2.60	2.76	2.86	3.17	3.66
7.	Clay, wet and sticky	2.50	2.60	2.76	2.86	3.17	3.66

15.8.4. Rates for Earthwork by Motorised Scrappers are tabulated below :—

TABLE 6.11.12

Rates for Excavation and Hauling by Motorised Scrapper.

Sl. No.	Soils	Lead one way haul in feet						
		1000	1500	2000	2500	3000	4000	5000
1	2	3	4	5	6	7	8	9
1.	Light or crumbly silt	1.72	1.83	2.01	2.23	2.34	2.66	3.06
2.	Sand and gravel	2.19	2.35	2.43	2.70	2.80	3.16	3.56
3.	Good common earth	1.78	1.95	2.10	2.34	2.47	2.81	3.13
4.	Clay, hard and tough	2.39	2.52	2.67	2.93	3.05	3.41	3.98
5.	Murum	2.23	2.39	2.52	2.74	2.84	3.20	3.60
6.	Hard murum	2.42	2.61	2.77	3.01	3.05	3.41	3.89
7.	Clay, wet and sticky	2.42	2.61	2.77	3.01	3.05	3.41	3.89

15.8.5. The rates for consolidation of earthwork by sheepsfoot rollers are given below :—

Analysis of rate of consolidation.

(a) Cost of per CFC dozing @ Rs. 32 per hour	Rs. 0.38
(b) Cost of water CFC	Rs. 0.25
(c) Cost of Rolling output of twin drum sheepsfoot roller for 8″ depth layer and 10 passes.	72 CFC per hr.
Use rate per hour D.4 of tractor drawn roller	Rs. 15.1
Cost per CFC of rolling	Rs.0.21

15.9. EARTHWORK BY MANUAL LABOUR

15.9.1. The analysis of rates for earthwork by manual labour is given below :—

TABLE 7.3.4. (*iii*)

Sl. No.	Type of soil	Rates of excavation for distance (CFR) .25	.5	1.0	1.5	2.0	2.5
1	2	3	4	5	6	7	8
1.	Sand & silt	0.62-0.89	0.75-1.0	1.03-1.23	1.27-1.47	1.53-1.75	1.79-2.00
2.	Top soil	0.89-1.25	1.0-1.4	1.23-1.68	1.47-1.90	1.73-2.16	2.00-2.42
3.	Common earth	1.07-1.57	1.2-1.7	1.48-1.98	1.72-2.22	1.98-2.54	2.24-3.74
4.	Clay, light	1.43-1.87	1.56-2.1	1.84-2.38	2.08-2.62	2.34-2.88	2.60 3.14
5.	Clay, heavy	1.67-2.37	1.8-2.8	2.08-2.78	2.32-3.02	2.58-2.58	2.34-3.54
6.	Soft rock	2.72-4.72	2.89-4.89	3.27-5.27	3.62-5.62	3.98-5.98	4.36-6.36

15.9.2. The following is the analysis of rates of transport by donkeys.

TABLE 7.6.1.

Lead	Time taken per trip: Haulage(min.)	Loading & unloading (min.)	Total (min.)	No. of trips per day	Rate per CFC (Rs.)
200	1.50	2.0	3.5	137	1.8
300	2.25	2.0	4.25	113	2.1
400	3.00	2.0	5.0	96	2.6
500	3.75	2.0	5.75	84	3.0
600	4.50	2.0	6.50	74	3.4
700	5.25	2.0	7.25	66	3.8
800	6.00	2.0	8.00	60	4.2
900	6.75	2.0	8.75	55	4.6
1000	7.50	2.0	9.50	50	5.0
1500	10.25	2.0	12.25	39	6.4
2000	15.00	2.0	17.00	28	8.9
2500	18.75	2.0	20.75	23	10.8

15.10. Drilling and Blasting

15.10.1. The analysis of rates of drilling and blasting is given below :—

9.3.2. Drilling cost will vary according to the type of rock drilled. A typical analysis of cost of drilling in Basalt is given below. In the case of hard and abrasive rock like Granite or Sandstone, the cost will increase by 25 to 30% depending on the nature of rock. About 6 Rft. of drilling in Basalt is required to blast 100 cft.

Analysis of rate for drilling one R.ft. in Basalt

Drilling 20 ft. deep holes from 40 mm. at top to 33 mm. at bottom with Carbide tipped Coromont drills.

a.	Average cost of 8 sets of Coromont drills of different length.		Rs. 90
	Average R.Ft. drilled by the drills allowing for breakages. 550ft.		
	Cost of drill per R.Ft. of drilling.		Rs. 0.18
b.	Sharpening charge L.S.		Rs. 0.04
c.	Pipes & pipe fittings.		Rs. 0.08
d.	Machinery charges:		
	Depreciation of Jackhammer @3% per month.		Rs. 30
	Depreciation per hour. @200 hrs. per month		Rs. 0.15
	A jackhammer can drill 100 rft. in 8 hrs.		
	Depreciation per rft.	$\frac{8 \times 0.15}{100} =$	Rs. 0.012
	Repairs @ 40% of depreciation.		Rs. 0.005
e.	Air Charges.		
	Using 315 C.F.M. air compressor		
	Supplying air to 4 Jackhammers.		
	Use-rate of air compressor.		Rs. 14/-
	Cost of air supplied to 1 Jackhammer		Rs. 3.5
	Hence, cost of air for 0.08 hour of		
	Jack hammer per rft.	0.08×3.5	Rs. 0.28
			Rs. 0.11
f.	Labour per rft.		

Abstract

(a)	Cost of drill	Rs. 0.18
(b)	Sharpening charges	Rs. 0.04
(c)	Pipes & pipe fittings	Rs. 0.08
(d)	Machinery charges	Rs. 0.17
(e)	Air Charges	Rs. 0.28
(f)	Labour	Rs. 0.11
	Total rate drilling per rft.	Rs. 0.707

15.11. Brickwork and Lining

15.11.1. Typical analysis for rate of common brickwork in walls is given below :—

TABLE 15.11.1

Analysis of Cost per CFC of Brick Masonry

1. Size of Bricks: 9″×4-3/8″×2-11/16″
2. Brief Specifications : Cement Mortar 1: 4. Thickness of joint 5/15″ (single storey). Height not exceeding 15 ft. in superstructure.

Sl. No.	Items	Unit	Quantity	Rate	Amount	Remarks
1	2	3	4	5	6	7
1.	*Brick I Class*					
	1.1 Cost ex-kiln	Nos. 1000	1350	22.0	29.70	Tables 11.1.3, & 15.3.1. 4% break-age of bricks.
	1.2 Transport to the site of work 3 miles	1000	1350	5.0	6.75	Table 8.4.5.
2.	*Sand*					
	2.1 Cost of quarrying or manufacture	CFC	0.31	10.0	3.10	Table 15.3.1
	2.2 Transport to the site of work 3 miles	CFC	0.31	6.7	2.08	Table 13.4.5
	2.3 Storage & handling upto mills.	CFC	0.31	2.0	0.62	
3.	*Cement*					
	3.1 Cost ex-project godown.	Cwt.	5.7	5.0	28.59	Table 11.2.5 & 15.3.1.
	3.2 Transport to the site of work	—	—	—	—	
	3.3 Storage and handling upto mills	Cwt.	5.7	0.02	[illegible]	

TABLE 15.11.1—contd.

1	2	3	4	5	6	7
4.	*Water*	CFC	—	—	1.00	
5.	*Mixing of Mortar* Male mazdoor Female mazdoor	CFC	26.0	0.021	0.55	Table 11.3.3
6.	*Lead & Lift*					
	6.1 Scaffolding	CFC	1.0	1.6	1.60	
	6.2 Lead & lift of bricks.					
	6.3 Lead & lift of mortar	CFC	1.0	1.5	1.50	
7.	*Laying and Curying including Soaking*					
	7.1 Cleaning & racking Male mazdoor. 7.2 Soaking.	No.	No. 1/8	1.75	0.22	
	7.3 Cost of laying including handling, site lead & lift for one storey.					
	Mason I class	No.	1.25	5.0	6.25	Table 15.2.1.
	Mason II class	No.	1.25	3.5	4.38	
	Male Mazdoor	No.	2.0	1.75	3.50	
	Female Mazdoor	No.	2.0	1.25	2.50	
	Bhishti or water carrier.	No.	0.5	2.5	1.25	
	7.4 Wetting Bhishti or water carrier.	Included under item 7.3				

Total Primary Rate 93.01

Say, Rs. 93 per CFC

TABLE 15.11.2

Analysis of Cost per CFC of Brick Masonry

1. Size of Bricks : 9"×4-3/8"×2-11/16"

2. Brief specifications: R.C.M. 4:1:20; Thickness of joint 5/16" (single storey)— Height not exceeding 15 ft.

Sl. No.	Item	Unit	Quantity	Rate	Amount	Remarks
1	2	3	4	5	6	7
1.	*Brick I Class*	Nos.				
	1.1 Cost ex-kiln.	1000	1350	22.0	29.70	Tables 11.1.3., 15.3.1. 4% breakage of bricks.
	1.2 Transport to the site of work 3 miles.	1000	1350	5.0	6.75	Table 8.4.5.
2.	*Sand*					
	2.1 Cost of quarrying or manufacture.	CFC	0.31	10.0	3.10	Table 15.3.1.
	2.2 Transport to the site of work 3 miles	CFC	0.31	6.7	2.08	Table 8.4.5.
	2.3 Storage & handling upto mills.	CFC	0.31	2.0	0.62	
3.	*Cement*					
	3.1 Cost ex-project godown.	Cwt.	4.9	5.0	24.50	Tables 11.2.5., 15.3.1.
	3.2 Transport to the site of work	—	—	—	—	
	3.3 Storage & handling upto mills.	Cwt.	4.9	0.02	0.10	

TABLE 15.11.2.—Contd.

1	2	3	4	5	6	7
4.	*Water*	CFC	—	—	1.00	
5.	*Admixtures—Surkhi*					
	5.1 Purchase or manufacturing cost 5.2 Transport to the site of work	CFC	1.3 FC	30.00	0.39	
	5.3 Storage & handling up to mills	CFC	1.3 FC	2.00	0.03	
6.	*Mixing of Mortar* Male Mazdoor Female Mazdoor	FC	2.6	0.035	0.91	Table 11.3.3.
7.	*Lead & Lift*					
	7.1 Scaffolding	CFC	1.0	1.0	1.00	
	7.2 Lead & lift of bricks. 7.3 Lead & lift of mortar	CFC	1.0	1.5	1.50	
8.	*Laying and Curing including Soaking*					
	8.1 Cleaning & racking Male mazdoor. 8.2 Soaking.	No.	No. 1/8	1.75	0.22	
	8.3 Cost of laying including handling, site lead & lift for one storey.					
	Mason I Class	No.	1.25	5.0	6.25	Table 15.2.1
	Mason II Class	No.	1.25	3.5	4.38	
	Male Mazdoor	No.	2.0	1.75	3.50	
	Female Mazdoor	No.	2.0	1.25	2.50	
	Bhishti or water carrier	No.	0.5	2.5	1.25	
	8.4 Wetting. Bhishti or water carrier.	Included under item 8.3				
		Total Primary Rate			89.78	

Say, Rs. 90 per CFC

TABLE 15.11.3

Analysis of Cost per CFC of Brick Masonry

Size of Bricks: 9″ × 4-3/8″ × 2-11/16″

2. Brief specifications : Lime-sand mortar (2 S.M.) 1:3, thickness of joint: 5/16″ (single storey)—Height not exceeding 15 ft. (in superstructure).

Sl. No.	Items	Unit	Quantity	Rate	Amount	Remarks
1	2	3	4	5	6	7
1.	*Brick I Class*	Nos.				
	1.1 Cost ex-kiln.	1000	1350	22.0	29.70	Tables 11.1.3, 15.3.1. 4% breakage of bricks.
	1.2 Transport to the site of work 3 miles	1000	1350	6.0	6.75	Table 8.4.5.
2.	*Sand*					
	2.1 Cost of quarrying or manufacture.	CFC	0.29	10.0	2.90	Table 15.3.1
	2.2 Transport to the site of work 3 miles	CFC	0.29	10.0	2.90	Table 8.4.5.
	2.3 Storage & handling upto mills.	CFC	0.29	2.0	0.58	
3.	*Lime*					
	3.1 Cost ex-project godown 3.2 Transport to the site of work	Cwt.	5.2	3.0	15.60	Tables 11.2.5 15.3.1.
	3.3 Storage and handling upto mills.	,,	5.2	0.02	0.10	
4.	*Water*	CFC	—	—	1.00	

TABLE 5.11.3—contd.

1	2	3	4	5	6	7
5.	*Grinding of Mortar*	CFC	0.29	2.00	2.32	
					61.03	
6.	*Lead & Lift*					
	6.1 Scaffolding	CFC	1.0	1.0	1.00	
	6.2 Lead & lift of bricks 6.3 Lead & lift of mortar	CFC	1.0	1.5	1.50	
7.	*Laying and Curing including Soaking*					
	7.1 Cleaning & racking Male mazdoor. 7.2 Soaking	No.	No. 1/8	1.75	0.22	
	7.3 Cost of lying including & handling, site lead & lift for one storey.					
	Mason I Class	No.	1.25	5.0	6.25	Table 15.2.1
	Mason II Class	No.	1.25	3.5	4.38	
	Male Mazdoor	No.	2.0	1.75	3.50	
	Female Mazdoor	No.	2.0	1.25	2.50	
	Bhishti or water carrier.	No.	0.5	2.5	1.25	
	7.4. Wetting Bhishti or water carrier	Included under item 7.3				
		Total Primary Rate			81.63	

Say, Rs. 82 per CFC

TABLE 15.11.4

Analysis of Cost per CFC of Brick Masonry

1. Size of Bricks: 9″ × 4-3/8″ × 2-11/16″.

2. Brief Specifications : Cement, Lime & Sand Mortar (CLM) 1:1:6. Thickness of joint: 5/16″ (single storey)—Height not exceeding 15 ft. (in superstructure).

Sl. No.	Items	Unit	Quantity	Rate	Amount	Remarks
1	2	3	4	5	6	7
1.	*Brick I Class*					
	1.1 Cost ex-kiln	Nos. 1000	1350	22.0	29.70	Tables 11.1.3., 15.3.1. 4% breakage of bricks.
	1.2 Transport to the site of work 3 miles	,,	1350	5.0	6.75	Table 8.4.5.
2.	*Sand*					
	2.1 Cost of quarrying or manufacture	CFC	0.29	10.0	2.90	Table 15.3.1.
	2.2 Transport to the site of work 3 miles	,,	0.29	6.7	2.08	Table 8.4.5.
	2.3 Storage & handling upto mills	,,	0.29	2.0	0.52	
3.	*Cement*					
	3.1 Cost ex-project godown. 3.2 Transport to the site of work	Cwt.	3.9	5.0	19.50	Tables 11.2.5., 15.3.1.
	3.3 Storage and handling upto mills	,,	3.9	0.02	0.08	
4.	*Water*	CFC	—	—	1.0	

TABLE 15.11.4—contd.

1	2	3	4	5	6	7
5.	*Admixtures—Lime*					
	5.1 Purchase or manufacturing cost. 5.2 Transport to the site of work	IND	2.6	3.0	7.80	Tables 11.2.5., 15.3.1.
	5.3 Storage & handling up to mills	IND	2.6	0.02	0.05	
6.	*Mixing of mortar*					Table
	Male mazdoor Famale Mazdoor	FC	26.0	0.29	0.75	11.3.3.
7.	*Lead & Lift*					
	7.1 Scaffolding	CFC	1.0	1.0	1.00	
	7.2 Lead & lift of bricks 7.3 Lead & lift of mortar	,,	1.0	1.5	1.50	
8.	*Laying and Curing including Soaking*					
	8.1 Cleaning & racking Male mazdoor 8.2 Soaking.	No.	No. 1/8	1.75	0.22	
	8.3 Cost of laying including handling, site lead & lift for one storey.					
	Mason I Class	No.	1.25	5.0	6.25	Table 15.2.1.
	Mason II Class	No.	1.25	3.5	4.38	
	Male Mazdoor	No.	2.0	1.75	3.50	
	Female Mazdoor	No.	2.0	1.25	2.50	
	Bhishti or water carrier	No.	0.5	2.5	1.25	
	8.4. Wetting Bhishti or water carrier	Included under item 8.3				
		Total Primary Rate			91.79	

Say, Rs. 92 per CFC

TABLE 15.11.5.

Analysis of Cost per CFS of Tile-lining

1. Size of Tiles : 12"×6"×2"
2. Brief specifications: 2 layers in bed. Bottom layer 3/8" in C.M. 1:5, sandwitched layer 5/8" in CM 1:3, 1/4" layer of cement plaster on sandwitched layer in CM 1:3, vertical joints 1/4" thick in CM 1:5 for bottom layer and CM 1:3 for top layer joints.

Sl. No.	Items	Unit	Quantity	Rate	Amount	Remarks
1	2	3	4	5	6	7
1.	*Bricks Class I*					
	1.1 Cost ex-kiln	Nos. 1000	380	35.0	13.30	Table 15.3.1; 5% breakage & 3/8" vertical joints.
	1.2 Transport to the site of work 3 miles	,,	380	6.25	2.38	25% extra bricks transportation rate.
2.	*Sand*					
	2.1 Cost of quarrying or manufacture.	CFC	0.12	10.20	1.20	Table 15.3.1.
	2.2 Transport to the site of work 3 miles	CFC	0.12	6.7	0.80	Table 8.4.5.
	2.3 Storage & handling upto mills	CFC	0.12	2.0	0.24	
3.	*Cement*					
	3.1 Cost ex-project godown 3.2 Transport to the site of work	Cwt.	2.8	5.0	14.00	Table 15.3.1
	3.3 Storage and handling upto mills	Cwt.	2.8	0.02	0.06	

TABLE 15.11.5—contd.

1	2	3	4	5	6	7
4.	*Water*	CFC	—	—	0.50	
5.	*Mixing of mortar*					
	Male Mazdoor Female Mazdoor	FC	12.0	0.21	0.25	Table 11.3.3
6.	*Laying and Curing including Soaking*					
	6.1 Cleaning & racking Male mazdoor 6.2 Soaking	No.	No. 1/8	1.75	0.22	
	6.3 Cost of laying including handling site lead & lift for one storey.					
	Mason I class	No.	0.75	5.0	3.75	Table 15.2.1
	Mason II class	No.	0.75	3.5	2.68	
	Male Mazdoor	No.	1.00	1.75	1.75	
	Female Mazdoor	No.	1.00	1.25	1.25	
	Bhishti or water carrier	No.	0.50	2.5	1.25	
8.	6.4 Wetting					
	Bhishti or water carrier	Included under item 6.3.				
			Total Primary Rate		43.63	
			Say, Rs. 44/- per CFC			

NOTE—For lining on slopes Rs. 0.5 extra may be allowed for every 3 ft. height or part thereof.

15.12. Stone Masonry

15.12.1. Typical analysis of rates for stone masonry in various proportions of mortar are given below :—

TABLE 15.12.1

Analysis per CFC of Stone Masonry for hearting in Dams—Height upto 100 feet.

Brief Specifications :—R.R. Masonry in CM 1:4.

Sl. No.	Item	Unit	Quantity	Rate	Amount	Remarks
1	2	3	4	5	6	7
1.	*Rubble*					
	1.1 Quarrying	CFC	1.0	18.0*	18.0	*Table 15.3.1.
	1.2 Dressing Masons	No.	1.0	3.5*	3.5	*Table 15.2.1.
	1.3 Transport to the site of work say 3 miles.	CFC	1.0	7.3*	7.3	*Table 8.4.5.
2.	*Sand*					
	2.1 Quarrying or manufacturing	CFC	0.54	10.0*	5.4	*Table 15.3.1.
	2.2 Transport to site of work say 3 miles.	CFC	0.54	7.3*	3.9	*Table 8.4.5.
	2.3 Storage & handling upto mills.	CFC	0.54	2.0	1.1	
3.	*Cement.*					
	3.1 Cost at source of supply 3.2 Transport to site of work	Cwt.	9.0	5.0	45.0	Table 15.3.1.
	3.3 Storage & handling upto mills	Cwt.	9.0	0.02	0.2	

TABLE 15.12.1—contd.

1	2	3	4	5	6	7
4.	*Water & Curing*	CFC	1.0	4.0	4.0	
5.	*Mixing of mortar*					
	By manual labour Male Mazdoor Female Mazdoor Bhishti or water carrier	CFC	0.45	2.5	1.1	
6.	*Lead & Lift*					
	6.1 Scaffolding	CFC	1.0	0.25	0.3	
	6.2. Lead & lift of stone and mortar by crane weighted lead 100′	No.	0.5	15.0	7.5	Table 13.7.2
	6.3 —do— 80′ lift	CFC	1.0	11.2	11.2	Para 13.7.3.
7.	*Cost of Laying including Handling*					
	Mason I Class	No.	1.0	5.0*	5.0	*Table 15.2.1
	Mason II Class	No.	1.0	3.5	3.5	
	Male Mazdoor	No.	2.0	1.75	3.5	
	Female Mazdoor	No.	2.0	1.25	2.5	
	Bhishti or water carrier	No.	0.2	2.5	0.5	
			Total	Primary Rate	123.5	

Or say, Rs. 124/-

NOTES : 1. Transport by 'A' class road only provided.
2. Rate of Rs. 10.0 per CFC of sand provided, includes washing charges also.
3. Bond stones and extra for face masonry not included.
4. Lift only upto 100′ height and lead for 100′ only.

TABLE 15.12.2

Analysis per CFC of Stone Masonry for hearting in Dams—Height upto 100 ft.

Brief Specifications : R.R. Masonry in CM 1:3.

Sl. No.	Item	Unit	Qty.	Rate	Amount	Remarks
1	2	3	4	5	6	7
1.	*Rubble*					
	1.1. Quarrying	CFC	1.0	18.0	18.0	Table 15.3.1.
	1.2. Dressing Masons	No.	1.0	3.5	3.5	Table 15.2.1
	1.3 Transport to the site of work say 3 miles	CFC	1.0	7.3	7.3	Table 8.4.5.
2.	*Sand*					
	2.1 Quarrying or manufacturing	CFC	0.54	10.0	5.4	Table 15.3.1.
	2.2 Transport to site of work say 3 miles.	CFC	0.54	7.3	3.9	Table 8.4.5.
	2.3 Storage & handling upto mills	CFC	0.54	2.0	1.1	
3.	*Cement.*					
	3.1. Cost at source or supply. 3.2 Transport to site of work	Cwt.	12.0	5.0	60.0	Table 15.3.1.
	3.3 Storage & handling upto mills.	Cwt.	12.0	0.02	0.2	

TABLE 15.12.2—contd.

1	2	3	4	5	6	7
4.	*Water & Curing*	CFC	1.0	4.0	4.0	
5.	*Mixing of mortar*					
	By manual labour Male Mazdoor Female Mazdoor Bhishti or water carrier	CFC	0.45	2.5	1.1	
6.	*Lead & Lift*					
	6.1 Scaffolding	CFC	1.0	0.25	0.3	
	6.2 Lead & lift of stone mortar by Crane—weighted lead 100′.	No.	0.5	15.0	7.5	Table 13.7.2.
	6.3 —do— Lift 80′.	CFC	1.0	11.2	11.2	
7.	*Cost of laying including Handling*					
	Mason I Class	No.	1.0	5.0	5.0	Table 15.2.1.
	Mason II Class	No.	1.0	3.5	3.5	
	Male Mazdoor	No.	2.0	1.75	3.5	
	Female Mazdoor	No.	2.0	1.25	2.5	
	Bhishti or water carrier	No.	0.2	2.5	0.5	
		Total	Primary Rate		138.5	

Or say, Rs. 139/-

NOTES : 1. Transport by 'A' Class road only provided.
2. Rate of Rs. 10.0 per CFC of sand provided, includes washing charges also.
3. Bond stones and extra for face masonry not included.
4. Lift only upto 100′ height and lead for 100′ only.

TABLE 15.12·3.

Analysis per CFC of Stone Masonry for hearting in Dams - height upto 100 ft.

Brief specifications : Random Rubble Masonry in C.M. $1:2\frac{3}{4}$

Sl. No.	Item	Unit	Qty.	Rate	Amount	Remarks
1	2	3	4	5	6	7
1.	*Rubble*					
	1.1 Quarrying	CFC	1.0	18.0	18.0	Table 15.3.1.
	1.2 Dressing Masons	No.	1.0	3.5	3.5	Table 15.2.1.
	1.3 Transport to the site of work say 3 miles	CFC	1.0	7.3	7.3	Table 8.4.5.
2.	*Sand*					
	2.1 Quarrying or manufacturing	CFC	0.54	10.0	5.4	Table 15.3.1.
	2.2 Transport to site of work say 3 miles.	CFC	0.54	7.3	3.9	Table 8.4.5.
	2.3 Storage & handling upto mills.	CFC	0.54	2.0	1.1	
3.	*Cement*					
	3.1 Cost at source of supply 3.2 Transport to site of work	Cwt.	13.1	5.0	65.5	Table 15.3.1
	3.3 Storage & handling upto mills	Cwt.	13.1	0.02	0.3	
4.	*Water & Curing*	CFC	1.0	4.0	4.0	

TABLE 15.12.3—contd.

1	2	3	4	5	6	7
5.	*Mixing of Mortar* (By manual labour)					
	Male Mazdoor Female Mazdoor Bhishti or water carrier	CFC	0.45	2.5	1.1	
6.	*Lead & Lift*					
	6.1 Scaffolding	CFC	1.0	0.25	0.3	
	6.2 Lead & lift of stone mortar by crane weighted lead 100′.	No.	0.5	15.0	7.5	Table 13.7.2
	6.3 -do- lift 80′.	CFC	1.0	11.2	11.2	Para 13.7.3.
7.	*Cost of laying including Handling*					
	Mason I class	No.	1.0	5.0	5.0	Table 15.2.1.
	Mason II class	No.	1.0	3.5	3.5	
	Male Mazdoor	No.	2.0	1.75	3.5	
	Female Mazdoor	No.	2.0	1.25	2.5	
	Bhishti or water carrier	No.	0.2	2.50	0.5	
	Total Primary Rate				144.1	
			Or say, Rs. 144/-			

NOTES: 1. Transport by 'A' class road only provided.

2. Rate of Rs. 10.0 per CFC of sand provided, includes washing charges also.

3. Bond stones and extra for face masonry not included.

4. Lift only upto 100 ft. height and lead for 100 ft. only.

TABLE 15.12.4.

Analysis per CFC of Stone Masonry for hearting in Dams—height upto 100 ft.

Brief Specifications : Random Rubble Masonry in red cement mortar 1:2¾

Sl. No.	Item	Unit	Qty.	Rate	Amount	Remarks
1	2	3	4	5	6	7
1.	*Rubble*					
	1.1 Quarrying.	CFC	1.0	18.0	18.0	Table 15.3.1.
	1.2 Dressing Masons.	No.	1.0	3.5	3.5	Table 15.2.1.
	1.3 Transport to the site of work say 3 miles.	CFC	1.0	7.0	7.3	Table 8.4.5.
2.	*Sand*					
	2.1 Quarrying or manufacturing	CFC	0.54	10.0	5.4	Table 15.3.1.
	2.2 Transport to site of work say 3 miles.	CFC	0.54	7.3	3.9	Table 8.4.5.
	2.3 Storage & handling upto mills.	CFC	0.54	2.0	1.1	
3.	*Cement*					
	3.1 Cost at source of supply 3.2 Transport to site of work	Cwt.	10.45	5.0	52.3	Table 15.3.1.
	3.3 Storage & handling upto mills.	Cwt.	10.45	0.02	0.2	
4.	*Water & Curing.*	CFC	1.0	4.0	4.0	

TABLE 15.12.4.—contd.

1	2	3	4	5	6	7
5.	*Admixtures (Surkhi)*					
	5.1 Purchase or manufacturing cost.					
	5.2 Transport to site	CFC	0.086	7.5	2.5	Table 15.3.1.
	5.3 Storage & handling upto mills					
6.	*Mixing of Mortar* (By manual labour)					
	Male Mazdoor Female Mazdoor Bhishti or water carrier	CFC	0.45	2.5	1.1	
7.	*Lead and Lift*					
	7.1 Scaffolding.	CFC	1.0	0.25	0.3	
	7.2 Lead & lift of stone & mortar by crane, weighted lead 100′	No.	0.5	15.0	7.5	Table 13.7.2.
	7.3 -do- lift 80′.	CFC	1.0	11.2	11.2	
8.	*Cost of laying including handling*					
	Mason I Class	No.	1.0	5.0	5.0	Table 15.2.1.
	Mason II Class	No.	1.0	3.5	3.5	
	Male Mazdoor	No.	2.0	1.75	3.5	
	Female Mazdoor	No.	2.0	1.25	2.5	
	Bhishti or water carrier.	No.	0.2	2.5	0.5	
			Total Primary Rate		133.3 Or say, Rs. 133/-	

NOTES : 1. Transport by 'A' Class road only provided.
2. Rate of Rs. 10.0 per CFC of sand provided includes washing charges also.
3. Bond stores and extra for face masonry not included.
4. Lift only upto 100′ height and lead for 100′ only.

TABLE 15.12.5

Analysis per CFC of Stone Masonry for hearting in Dams—height upto 100 *ft.*

Brief Specifications : Random rubble masonry in red cement mortar 1:4.

Sl. No.	Item	Unit	Quantity	Rate	Amount	Remarks
1	2	3	4	5	6	7
1.	*Rubble*					
	1.1 Quarrying	CFC	1.0	13.0	18.0	Table 15.3.1.
	1.2 Dressing Masons	No.	1.0	3.5	3.5	Table 15.2.1.
	1.3 Transport to the site of work say 3 miles.	CFC	1.0	7.3	7.3	Table 8.4.5.
2.	*Sand*					
	2.1 Quarrying or manufacturing	CFC	0.54	10.0	5.4	Table 15.3.1.
	2.2 Transport to site of work say 3 miles.	CFC	0.54	7.3	3.9	Table 8.4.5.
	2.3 Storage & handling upto mills.	CFC	0.54	2.0	1.1	
3.	*Cement*					
	3.1 Cost at source of supply 3.2 Transport to site of work	Cwt.	8.1	5.0	40.5	Table 15.3.1.
	3.3 Storage and handling upto mills		8.1	0.02	0.2	
4.	*Water & Curing*	CFC	1.0	4.0	4.0	

TABLE 15.12.5—contd.

1	2	3	4	5	6	7
5.	*Admixtures (Surkhi)*					
	5.1 Purchase or manufacturing cost. 5.2 Transport to site 5.3 Storage and handling upto mills.	CFC	0.025	75.0	1.9	
6.	*Mixing of Mortar* (By manual labour)					
	Male Mazdoor Female Mazdoor Bhishti or water carrier.	CFC	0.45	2.5	1.1	
7.	*Lead and Lift*					
	7.1 Scaffolding	CFC	1.0	0.25	0.3	
	7.2 Lead and lift of stone & mortar by crane, weighted lead 100′	No.	0.5	15.0	7.5	Table 13.7.2.
	7.3 Weighted lift 80′	CFC	1.0	11.2	11.2	Table 13.7.3.
8.	*Cost of laying including handling*					
	Mason I Class	No.	1.0	5.0	5.0	
	Mason II Class	No.	1.0	3.5	3.5	
	Male Mazdoor	No.	2.0	1.75	3.5	
	Female Mazdoor	No.	2.0	1.25	2.5	
	Bhishti or water carrier	No.	0.2	2.5	0.5	
		Total Primary Rate		Rs.	120.9	

Or say, Rs. 121/-

NOTES: 1. Transport by 'A' class road only provided.
2. Rate of Rs. 10.0 per CFC of sand provided, includes washing charges also.
3. Bond stones and extra for face masonry not included.
4. Lift only upto 100 ft. height and lead for 100 ft. only.

TABLE 15.12.6

Analysis of Cost per CFC of Stone Rip-Rap or Pitching

Brief specifications: Hand-packed

Sl. No.	Item	Unit	Qty.	Rate	Amount	Reference
1	2	3	4	5	6	7
1.	Rubble stone at quarry including spalls.	CFC	1.15	12.0	13.80	
2.	*Labour*					
	2.1 Mason II Class	No.	0.5	3.5	1.75	
	2.2 Male Mazdoor	,,	1.5	1.75	2.63	
	2.3 Female Mazdoor	,,	1.5	1.25	1.87	
	2.4 Other workcharged establishment	—	—	—	—	
3.	Carriage of rubble stone & spalls from quarry to worksite say 3 miles.	CFC	1.15	7.3	8.40	Table 8.4.5.
4.	Sundries & T. & P.	L.S.	—	—	0.53	
			Total Primary Rate		28.98	

Say, Rs. 29/- per CFC

TABLE **15.12.7.**

Analysis per CFC of Stone Masonry Facework (Tungabhadra— Andhra)

Brief specification :—Face stone masonry in R.C.M. $1:2\frac{3}{4}$ (Cement & Surkhi mixed by weight)

Sl. No.	Item	Unit	Quantity	Rate	Amount	Remarks
1	2	3	4	5	6	7
1.	*Rubble*					
	1.1 Quarrying 1.2 Dressing Massons	CFC	1.05	138.0	144.90	
	1.3 Transport to the site of work	CFC	1.05	20.63	21.63	Lead not given
2.	*Sand* (By Lorry).					
	2.1 Quarrying or manufacturing including haulage	CFC	0.53	8.125	4.31	
	2.2 Transport to site of work	CFC	0.55	16.875	8.94	
	(By Rly. Wagon, 26 Miles)					
	2.3 Storage & handling upto mills.					
3.	*Cement*					
	3.1 Cost of source of supply	Cwt.	9.55	5.0	47.75	
	3.2 Transport to site of work	Cwt.	9.55	0.10	0.96	
	3.3 Storage and handling upto mills.	Cwt.	9.55	0.09	0.86	
4.	*Water*		*cost is negligible*			
5.	*Admixture, Surkhi*					
	5.1 Purchae or manufacturing cost	Cwt.	2.16	2.33	5.05	
	5.2 Transport to site	Cwt.	2.16	0.14	0.31	
	5.3 Storage and handling upto mills.					

TABLE 15.12.7.—contd.

1	2	3	4	5	6	7
6.	*Mixing Mortar*					
	(a) By manual Labour					
	Male Mazdoor.					
	Female Mazdoor					
					234.71	
	Bhishti or water carrier					
	or					
	(b) By mixer or manual					
	labour	CFC	0.42	3.0	1.26	
	Depreciation					
	Electric charges				0.84	
	Repairs				1.63	
	Consumable Materials					
	Operation Labour					
	Other Labour					
	(i) Male Mazdoor					
	(ii) Female Mazdoor					
	(iii) Bhishti or water carrier					
7.	*Lead & Lift*					
	7.1 Scaffolding				2.25	
	7.2 Lead & Lift of Stone }					
	7.3 Lead & Lift of Mortar }				2.25	
8.	*Cleaning & Curing*				5.14	This include cost of Cement slurrywire brush pumping, watering including running & maintenance of pumps & cost of hose pipes.
	8.1 Cleaning & Slurry					
	(a) Cement for slurry mortar					
	(b) Cleaning					
	Male Mazdoor					
	8.2 Cost of laying including handling					
	Mason 1st class	No.	1.0	3.38	3.38	
	Mason II class	No.	1.0	2.63	2.63	
	Male Mazdoor	No.	3.0	1.50	4.50	
	Female Mazdoor	No.	6.0	0.75	4.50	
	Bhishti or water carrier	No	0.16	0.75	0.13	
	8.3 Wetting					
9.	*Petty Supervision*					
	Contingencies				0.72	
10.	*Miscellaneous like template, etc*				1.62	
		Primary Rate			265.56	
	Sundry & Overhead charges	@35%			92.96	
				Total	358.52	
					Or say, Rs. 359	

15.13. Concrete

15.13.1. Typical analysis of rates of concrete by manual labour and mechanical means are given below :—

TABLE 15.13.1.

Analysis of Cost per CFC of Cement Concrete by Manual Labour

Brief specifications: 1:2:4 (1:6), aggregate is of broken stone of size upto 3/4″ gauge.

Sl. No.	Item	Unit	Quantity	Rate	Amount	Reference
1.	*Coarse Aggregate*					
	1.1 Quarrying & breaking stone to size up to 3/4″ gauge.	CFC	0.90	30.0	27.0	Tables 14.2.2 & 15.3.1.
	1.2 Transport from quarrysite to worksite —3 miles.	CFC	0.90	6.7	6.9	Table 8.4.5.
2.	*Sand*					
	2.1 Quarrying	CFC	0.45	10.0	4.5	Tables 14.2.2 & 15.3.1.
	2.2 Transport from quarrysite to worksite —3 miles.	CFC	0.45	6.7	3.0	Table 8.4.5.
3.	*Cement*					
	3.1 Ex-godown	Cwt.	18.1	5.0	90.5	Tables 14.2.2. & 15.3.1.
4.	*Labour*					
	4.1 Mixing, laying and vibrating etc. upto 10 ft. lift and 50 ft. lead.	CFC	1.0	15.0	15.0	
	4.2 Curing inclusive of cost of water.	CFC	1.0	0.5	0.5	
5.	*Sundries*	CFC	1.0	1.0	1.0	
		Total Primary Rate			147.5	

Say, Rs. 148 per CFC

TABLE 15.13.2.

Analysis of Cost per CFC of Cement Concrete by Manual Labour

Brief Specifications : 1:2:4 (1:6), aggregate is of broken stone of size 1½" gauge.

1.	Primary rate per CFC per Table 15.14.1.	Rs.	148/-
2.	Deduct cost due to difference in rate of coarse aggregate @ Rs. 30-27 = 3.0 per CFC of aggregate.	Rs.	2.7
		Rs.	145.3
		Say, Rs.	145 per CFC

TABLE 15.13.3.

Analysis of Cost per CFC of Cement-Concrete 1:1.5:3 (1:4.5) *by manual labour with broken stone of size upto* 3/4" *gauge*

1.	Primary rate per CFC per Table 15.14.1.			Rs.	148.0
2.	Add cost due to difference in quantity of cement 3.2 cwt. @ Rs. 5 per cwt.			Rs.	16.0
				Rs.	164.0
3.	Deduct cost due to difference in quantity of sand 2 FC @ Rs. 10 per CFC.	Rs.	0.2		
4.	Deduct cost due to difference in quantity of coarse aggregate 4 FC @ Rs. 30 per CFC.	Rs.	1.2		
		Rs.	1.4		1.4
				Rs.	162.6
				Say, Rs.	163 per CFC

TABLE 15.13.4.

Analysis of Cost per CFC of Cement-Concrete 1:2.5:5 (1:7.5) *by manual labour with broken stone of size* 1½" *gauge*

1.	Primary rate per CFC per Table 15.13.2.	Rs.	145.0
2.	Add cost due to difference in quantity of sand 1 FC @ Rs. 10 per CFC.	Rs.	0.1
3.	Add cost due to difference in quantity of aggregate 2 FC @ Rs. 27 per CFC.	Rs.	0.5
		Rs.	145.6
4.	Deduct cost due to difference in quantity of cement 3.2 cwt. @ Rs. 5.0 per cwt.	Rs.	16.0
		Rs.	129.6
		Say, Rs.	**130 per CFC**

TABLE 15.13.5.

Analysis of Cost per CFC of Cement-Concrete 1:3:6 (1:9) *by manual labour with broken stone of size* $1\frac{1}{4}''$ *gauge*

1.	Primary rate per CFC per Table 15.13.2	Rs.	145.0
2.	Add cost due to difference in quantity of sand 2 FC @ Rs. 10 per CFC.	Rs.	0.2
3.	Add cost due to difference in quantity of aggregate 4 FC @ Rs. 27 per CFC.	Rs.	1.1
		Rs.	146.3
4.	Deduct cost due to difference in quantity of cement 5.4 cwt. @ Rs. 5 per cwt.	Rs.	27.0
		Rs.	119.3
	Say,	Rs.	119 per CFC

TABLE 15.13.6.

Analysis of Cost per CFC of Cement-Concrete 1:4:8 (1:12) *by manual labour with broken stone of size* $1\frac{1}{4}''$ *gauge*

1.	Primary rate per CFC per Table 15.13.2.	Rs.	145.0
2.	Add cost due to difference in quantity of sand 3 FC @ Rs. 10 per CFC	Rs.	0.3
3.	Add cost due to difference in quantity of aggregate 7 FC @ Rs. 27 per CFC	Rs.	1.9
		Rs.	147.2
4.	Deduct cost due to difference in quantity of cement 8.4 cwts. @ Rs. 5 per cwt.	Rs.	42.0
		Rs.	105.2
	Say,	Rs.	105 per CFC

TABLE 15.13.7.

Analysis of Cost per CFC of Cement-Concrete 1:5:10 (1:15) *by manual labour with broken stone of size* $1\frac{1}{4}''$ *gauge*

1.	Primary rate per CFC per Table 15.13.2.	Rs.	145.0
2.	Add cost due to difference in quantity of sand 5 FC @ Rs. 10 per CFC	Rs.	0.5
3.	Add cost due to difference in quantity of aggregate 10 FC @ Rs. 27 per CFC	Rs.	2.7
		Rs.	148.2
4.	Deduct cost due to difference in quantity of cement 10 cwt. @ Rs. 5 per cwt.	Rs.	50·0
		Rs.	98.2
	Say,	Rs.	98 per CFC

TABLE 15.13.8.

Analysis of Cost per CFC of Cement-Concrete 1:8:16 (1:24) by manual labour with broken stone of size $1\frac{1}{4}''$ gauge

1.	Primary rate per CFC per Table 15.13.2.	Rs.	145.0
2.	Add cost due to difference in quantity of sand 6 FC @ Rs. 10 per CFC	Rs.	0.6
3.	Add cost due to difference in quantity of aggregate 12 FC, @ Rs. 27 per CFC	Rs.	3.2
		Rs.	148.8
4.	Deduct cost due to difference in quantity of cement 13 cwt. @ Rs. 5 per cwt.	Rs.	65.0
		Rs.	83.8
		Say, Rs.	84 per CFC

TABLE 15.13.9.

Analysis of Cost per CFC of Cement-Concrete by manual labour

Sl. No.	Item	Unit	Quantity	Rate	Amount	Remarks
1	*Coarse Aggregate*					
	1.1 Quarrying and sieving shingle	CFC	0.86	8.0	6.9	Tables 14.2.2. & 15.3.1.
	1.2 Transport from quarry-site to worksite, lead 3 miles.	CFC	0.86	6.7	5.8	Table 8.4.5.
2.	*Sand*					
	2.1 Quarrying.	CFC	0.43	10.0	4.3	Tables 14.2.2. & 15.3.1.
	2.2 Transport from quarry-site to worksite—3 miles.	CFC	0.43	6.7	2.9	Table 8.4.5.
3.	*Cement*					
	3.1 Ex-godown.	Cwt.	17.2	5.0	86.0	Tables 14.2.2. & 15.3.1.
4.	*Labour*					
	4.1 Mixing, laying and vibrating etc.	CFC	1.0	15.0	15.0	
	4.2 Curing inclusive of cost of water.	CFC	0.5	0.5	0.5	
5.	*Sundries*	CFC	1.0	1.0	1.0	
			Total Primary Rate.		Rs. 122.4	
					Say, Rs. 122 per CFC.	

ANNEXURE 9
(5.15.I)

PROGRESS SCHEDULE

UPPER HALF OF SPACE SHOWS ESTIMATED QUANTITIES AND PROGRESS.
LOWER HALF OF SPACE SHOWS ACTUAL QUANTITIES AND PROGESS TO DATE.
VERTICAL LINES INDICATE DATE OF PROGRESS SCHEDULE REPORT PERCENT.
COMPLETION GIVES AMOUNT OF PHYSICAL COMPLETION AT DATE OF REPORT.

JOB NO.____
PROJECT

DATE JAN.30.1950
REPORT NO. 15

% OF TOTAL	ITEM NO	ITEM	QUANTITY	UNIT	START	FINISH	PERCENT PHYSICAL COMPLETION	1 JULY	2 AUG.	3 SEPT.	4 OCT.	5 NOV.	6 DEC.	7 JAN.	8 FEB.	9 MAR.	10 APR.	11 MAY	12 JUNE	13 JULY	14 AUG.	15 SEPT.	16 OCT.	17 NOV.	18 DEC.	19 JAN.
					7.1.49	7.30.49		100																		
6.1%	1	MOVE ON & TEMPORARY BLDGS.			7.1.49	7.30.49		100																		
			7.600	C.Y.	7.15.49	10.15.49		0 16	50	84	100															
1.0%	2.	EXCAVATION	7.960	C.Y.	7.15.49	10.30.49		0 14	48	80	100															
			15.650	C.Y.	9.1.49	8.30.50	4			0 8	16	24	33	41	50	58	67	75	83	92	100					
0.9%	3.	BACKFILL & GRADING	15.348	C.Y.	9.1.49		34			0 8	18	26	31	34												
			970	C.Y.	8.1.49	10.30.49			0 34	63	100															
0.2%	4.	FOUNDATION CONCRETE	976	C.Y.	8.2.49	10.31.49			0 33	70	100															
			4.510	C.Y.	9.1.49	2.28.49	83			0 16	33	50	66	83	100											
0.9%	5.	STRUCTURAL CONCRETE	4.780	C.Y.	8.30.49		84			0 10	24	48	67	84												
			128.200	P.C.S	12.1.49	5.31.50	33						0 16	33	48	66	82	100								
1.7%	6.	BLOCK MASONRY	129.400	P.C.S	12.1.49		31						0 18	31												
		PERSONNEL:- SUPERVISORS	24																							
		MECHANICS & LABOURERS	360																							
			NO. OF DAYS PER MONTH					31	31	30	31	30	31	31	28	31	30	31	30	31	31	30	31	30	31	31

TABLE 15.13.10.

Analysis of Cost per CFC of Cement-Concrete 1:1.5:3 (1 : 4.5) *by Manual Labour with shingle as coarse aggregate*

1.	Primary rate per CFC per Table 15.13.9.			Rs.	122.0
2.	Add cost due to difference in quantity of cement 4.8 cwt. @ Rs. 5 per cwt.			Rs.	24.0
				Rs.	146.0
3.	Deduct cost due to difference in quantity of sand 2 F.C. @ Rs. 10 per CFC	Rs.	0.2		
4.	Deduct cost due to difference in quantity of shingle 4 FC @ Rs. 8 per CFC	Rs.	0.3		
		Rs.	0.5		
				Rs.	0.5
				Rs.	145·5
			Say,	Rs.	146 per CFC

TABLE 15.13.11.

Analysis of Cost per CFC of Cement-Concrete 1:3:6 (1:9) *by Manual Labour with shingle as coarse aggregate*

1.	Primary rate per C.F.C. per Table 15.13.9	Rs.	122.0
2.	Add cost due to difference in quantity of sand 2 F.C. @ Rs. 10 per CFC	Rs.	0.2
3.	Add cost due to difference in quantity of shingle 4 FC @ Rs. 8 per CFC	Rs.	0.3
		Rs.	122.5
4.	Deduct cost due to difference in quantity of cement 5.2 cwt. @ Rs. 5 per cwt.	Rs.	26.0
		Rs.	96.5
	Say,	Rs.	97 per CFC

TABLE 15.13.12

Analysis of Cost per CFC of Cement-Concrete 1:4:8 (1:12) *by Manual Labour with shingle as coarse aggregate*

1.	Primary rate per CFC per Table 15.13.9.	Rs.	122.0
2.	Add cost due to difference in quantity of sand 3 F.C. @ Rs. 10 per CFC	Rs.	0.3
3.	Add cost due to difference in quantity of shingle 6 F.C. @ Rs. 6 per CFC	Rs.	0.5
		Rs.	122.8
4.	Deduct cost due to difference in quantity of cement 7.9 cwt. @ Rs. 5 per cwt.	Rs.	39.5
		Rs.	83.3
	Say,	Rs.	83 per CFC

TABLE 15.13.13

Cost Analysis for mass concrete by machanical means for Dams above 100 *ft. height having total quantity of Concrete above* 400,000 *cu. yds.*

Sl. No.	Item	Unit	Qty.	Rate	Amount	Remarks
1	2	3	4	5	6	7
1.	*Coarse Aggregates*					
	1.1 Quarrying (without overburden).	CFC	0.94	9.61	9.03	
	1.2 Transport to crushers (mention lead) 3 miles.	CFC	0.94	7.80	7.33	Table 8.4.5.
	1.3 Crushing; processing & conveyance to stockpiles.	CFC	0.94	12.5	11.75	Para 14.10.1.
	1.4 Transport from stockpiles to batching plant.	CFC	0.94	5.53	5.20	Table 14.12.2.
2	*Sand*					
	2.1 Quarrying.	CFC	0.47	10.0	4.70	Table 15.3.1.
	2.2 Transport to site (mention lead) 3 miles.	CFC	0.47	17.8	3.67	Table 8.4.5.
	2.3 Crushing and processing if any.	CFC	0.47	5.0	2.35	
	2.4 Working.					
	2.5 Transport from stockpiles to batching plant.	CFC	0.47	5.53	2.60	Table 14.12.2.
3.	*Cement*					
	3.1 Cost ex-factory. 3.2 Rail or road transport and handling to site of work (mention lead)	Cwt.	10.0	5.0	50.0	Table 15.3.1.
	3.3 Storage and handling upto batching plant.	Cwt.	10.0	0.15	1.50	
4.	*Water*— with cost of hours.	CFC		—	2.00	
5.	*Admixture*					
	5.1 Cost of purchase or manufacture	—	—	—	—	
	5.2 Cost of transport.	—	—	—	—	
	5.3 Storage and handling upto batching plant.	—	—	—	—	

TABLE 15.13.13 —contd.

1	2	3	4	5	6	7
6.	*Batching, mixing & laying*					
	6.1. Batching & mixing	CFC	1.0	5.19	5.19	Para 14.13.3.
	6.2 Placing including transport from batching plant and vibrating.	CFC	1.0	23.56	23.56	Paras 14.13.4 14.13.5, and 14.13.6.
	6.3 Cleaning, slurry curing and finishing.					
	(a) Cement for slurry mortar.	CFC	—	—	5.00	
	(b) Sand blasting and cleaning with air and water	CFC	—	—	2.50	
	6.4 Compressed air for batching plant and other sundries.	CFC	—	—	1.00	
7.	*Other Items*					
	7.1 Pre-cooling plant and expenses.	—	—	—	—	
	7.2 Embedded system and operation cost.	—	—	—	—	
8.	*Workshop charges*	CFC	—	—	1.50	
				Total Primary Rate	138.88 Say, Rs. 139	

NOTES : 1. Overburden of the quarry not included.
2. Indirect expenses excluded.
3. The analysis is for basalt rock and for other varieties proportionate increase to be applied.
4. Cost of electric power is assumed as -/1/- per unit, near the site.
5. Formwork and cooling of concrete not included.

OBSERVATIONS

16.1. Introductory

16.1.1. Studies presented in Section B of Part I of the Report would provide the reader with the data relating to the rates on the various projects as made available to the Committee. The Projects can be grouped into 3 classes according to the Construction Agency employed *viz.*, the piecework contracts, the item rate contracts, and departmental agency.

TABLE 16.1.1.

Agencies employed for Execution of Works

Sl. No.	Type of project	Construction Agencies			Remarks
		Piecework	Unit rate contract	Departmental execution	
1	2	3	4	5	6
1.	Concrete Dams	—	Konar Vaitarna Rihand	Tilaiya Hirakud Bhakra Maithon Panchet Hill	
2.	Stone Masonry Dams	Hirakud Tungabhadra Peechi Perinchani Lower Bhawani Bhadra Massanjore Gandhisagar Matatila			
3.	Earth Dams and Dykes.	Panchet Hill Hirakud	Konar	Gangapur Nangal Hydel Sardasagar Matatila Maithon Lower Bhawani Panchet Hill Hirakud	

16.1.2. In the case of piecework and single contract execution the project authorities have expressed their total inability to furnishing breakup of rates, as they have made no time and motion studies.

16.1.3. As regards the departmental execution of works, the project authorities cooperated with us to the farthest extent possible consistent with the shape and condition of their accounts. They generally found it difficult to fill up the proformas sent to them but these can serve as a useful guide for future studies, and form Appendix 10.

16.2. THE BURDEN

16.2.1. This subject has been dealt with at length in Chapter 2. Figures for the average burden on projects, split up into various elements, are given in Table 16.2.1. The Cost column shows the names of projects where the departure from these figures is most pronounced.

TABLE 16.2.1.

Sl. No.	Items of Burden	Average(%)expense on the projects		Projects on which the expense (in brackets) has been above the average.
		Dams	Canals	
1	2	3	4	5
	Indirect Charges			
1.	K-Buildings	8.65	3.63	Perinchani (18.5) Hirakud Canals (5.6) Kakrapar (14.1) Durgapur (14.6) Durgapur Canal (6.2)
2.	Sercive Roads etc.	3.04	0.74	Bhakra-Nangal (6.9) Lower Bhawani (6.0) Hirakud (6.1) Kakrapar (7.1)
3.	Water supply etc.	1.62	0.31	Tungabhadra (Hyd.) (4.4) Panchet Hill (4.3)
4.	Electricity, Telephones etc.	1.86	0.26	Maithon (5.4) Tilaiya (6.4)
5.	Worksite amenities	1.13	0.44	Tungabhadra (Hyd.) (2.8) Bhadra Canals (1.5)
6.	Ordinary T&P	1.84	1.73	Gangapur (3.6) Matatila (2.7) Tungabhadra (Hyd) (6.1) Panchet Hill (2.9) Malampuzha (2.5) Durgapur (3.1)
7.	Loss on Stock	0.85	0.30	Tungabhadra (Hyd.) (2.6)
8.	Maintenance	0.36	0.44	Bhakra Nangal (2.0) Gandhisagar (2.0)
9.	Miscellaneous	0.71	0.59	Bhadra (3.3) Tungabhadra (And.) Canal (1.2)
	Overheads			
10.	Establishment	12.7	9.47	Gangapur (31.3) Tungabhadra (16.3) (Hyd) Perinchani (22.1) Maithon (16.8) Panchet Hill (14.2) Tilaiya (14.4) Kakrapar (21.6)
11.	Consulting Fees	0.26	0.04	Bhakra-Nangal (1.7) Maithon (1.2)
12.	Audit & Accounts	1.13	0.88	Mayurakshi (2.4) Mayurakshi Canal (1.4)

16.3. COMMENTS ON THE BURDEN

16.3.1. It will be noticed that the divergence in the figures for the elements of the burden is fairly wide, and a certain amount of control is needed on the project authorities to avoid waste and to provide a uniform standard for amenities and services. Using averages as the basis until better yardsticks are available, we would recommend the following scale for adoption on future projects.

TABLE 16.3.1.

Sl. No.	Item of work	Allowance as percentage of Direct cost		Remarks
		Dams	Canals	
1	2	3	4	5
	A. Indirect Charges			
1.	Buildings	5 to 10	3 to 6	Depending inversely on the size of the project
2.	Service Roads	3 to 4	½ to 1	
3.	Water Supply	1 to 2	½	
4.	Lighting			
5.	Compensation for accidents.	¾	½	
6.	Worksite amenities	2 to 3	1 to 1½	
7.	Small T&P	1		
8.	Testing	½	1/8	
9.	Losses on stock	½ to 1	¼ to ½	
10.	Maintenance during Construction	1	½ to 1	
11.	Miscellaneous	½ to 1	½ to 1	
	Total	16 to 24	8 to 12	
	B. Overheads			
1.	Establishment, Furniture, Stationery Bills etc.	10	7½	
2.	Consultants' fee.	¼ to ½	Nil.	
3.	Audit & Accounts	1	1	
	Total	11	8½	

16.4. EARTHWORK BY MACHINES

16.4.1 The output rates obtained for work by machines are governed by their use-rates and outputs. We have worked out the average expected outputs of the various machines in Chapter 6. The efficiency of a production can be judged against these yardsticks.

16.4.2. Tables 16.4.2. (*i*) and (*ii*) would show that the actual productive efficiency of Shovel and Draglines obtained over the various projects as against the averages.

TABLE 16.4.2. (*i*)

Comparative Statement of Output of Shovels per hour in C.F.C. Units (borrow measure)

Sl. No.	Project	Soil	Output per hour in CFC			Remarks
			Project Actual	R.&C.C.	Efficiency in %age	
1	2	3	4	5	6	7
1.	*3½ Cyds. Shovel*					
	(a) Nangal Hydel Channel	Light clay mixed with gravel	51.7	58	89	Soil is taken as clay, hard & tough.
	(b) Hirakud	Semi-pervious	47*	58	81	Soil is taken as murum. *Embankment measure is 51.82. The borrow measure is calculated.
2.	*2½ Cyds. Shovel*					
	(a) Bhakra	Rock	37*	40	92	*Worked out from the register of works for electric shovel.
		Mixed rock	24.8*	29	86	*Assumed as rock, poorly blasted.
	(b) Nangal	Light clay with gravel	42	45	94	
	(c) Hirakud	Semi-pervious	37	45	82	Murum assumed.
	(d) Maithon	Earth rock as 2:1	37	72	51	
3.	*1½ Cyds. Shovel* Hirakud	Semi-pervious	21	30	70	Murum assumed.

COMMENTS : The above table shows that the Maithon & Hirakud projects have a large leeway to make up.

TABLE 16.4.2. (*ii*)

Comparative Statements of Outputs of Draglines in CFC units (borrow) per hour

Sl. No.	Project	Soil	Output in CFC per hour			Remarks
			Project	R.&C.C.	Efficiency %age	
1	2	3	4	5	6	7
1.	$3\frac{1}{2}$ Cyds.					
	Tungabhadra (Andhra)	Slushy soft black cotton soil.	39.0	35	110	
2.	$2\frac{1}{2}$ Cyds.					
	(a) Harike	Earth	40.6	39	104	
	(b) Sarda hydel	Wet earth, sandy soil	25	25	100	Soil taken as clay, wet & sticky.
	(c) Tungabhadra (Andhra)	Slushy soil	28	25	112	
3.	$1\frac{1}{2}$ Cyds.					
	Tungabhadra (Andhra)	Slushy soil	20	21	96	
4.	1 Cyd.					
	Harike	Earth	19.5	20	98	
5.	$\frac{3}{4}$ Cyd.					
	(a) Harike	Earth	14	15	94	
	(b) Tungabhadra (Andhra)	Stiff black cotton soil	11	13	85	

COMMENTS : The above figures for efficiencies are more or less satisfactory.

16.5. Variation in Use Rates of Machines

16.5.1. It will be seen from the Table 16.5.1 that in the absence of any standard practice or rules on the subject of the 'Lives of Machines' each project has adopted whatever figure it could lay hands on. We have probed deeper into the subject and made a comparative study of the standards laid down in U.K., U.S.A., Canada, France, Germany, Newzealand, Australia, and Japan and our recommendations are contained in Tables 3.7.6 (*i*) and (*ii*).

16.5.2. Figures for expenditure on the repairs and overhaul of equipment are not being maintained on any project, and hence no comments are possible. We have, however, given yardstick (Table 3.12.3.) based on foreign practice to be used provisionally until Indian statistics are available.

16.5.3. While the figures for the actuals are not known the provision for the operation of equipment, as assumed by the projects, can be split up into the following for comparative studies.

(a) Life, Depreciation and Repairs.

(b) Labour, Fuel and Lubricants.

16.5.4. We have studied the following equipment :—

1. Shovels.

2. Draglines.

3. Tractor Dozers.

4. Motorised scrappers and Graders, and their combinations.

16.6. Shovels

16.6.1. Table 16.6.1. (*i*) gives a comparative study of life, depreciation and repairs.

Table 16.6.1. (*ii*) gives figures of provision under Labour and Fuel and Lubricants.

TABLE 16.6.1(*i*)

Life, Depreciation and Repairs of Shovel

N.B. : The bottom figures in each line are on the basis of Rates & Costs Committee recommendations regarding life and percentage of repairs & maintenance.

Sl. No.	Equipment/ Project	Cost in Lakhs	Life hours	Depreciation per hr.	Repairs (major & minor) per hr.	%age of repairs over depreciation	Total Depreciation & Repairs
1	2	3	4	5	6	7	8
1.	*3½ Cyds. Shovel*						
	(a) Bhakra	4.3	22000	19.31	33.63	200	57.94
			15000	28.4	28.4	100	56.90
	(b) Nangal	3.8	30000	12.67	7.60	60	20.27
			15000	25.34	25.34	100	50.68
	(c) Hirakud	3.6	16000	22.55	22.55	100	45.10
			15000	24.00	24.00	100	48.10
2.	*2½ Cyds. Shovel*						
	(a) Bhakra	3.4	22000	15.56	35.08	225	50.64
			15000	22.80	22.80	100	45.60
	(b) Nangal	3.8	30000	12.53	7.52	60	20.05
			15000	25.06	25.06	100	50.12
	(c) Hirakud	2.0	16000	15.10	15.10	100	30.20
			15000	16.00	16.00	100	32.00
	(d) Maithon	3.1	16000	22.50	22.50	100	45.00
			15000	24.00	24.00	100	48.00
	(e) Panchet Hill	3.5	16000	21.70	21.70	100	43.4
			15000	23.10	23.10	100	46.2
3.	*1½ Cyds. Shovel*						
	(a) Bhakra	3.0	17000	17.94	31.38	175	49.32
			12000	25.40	25.40	100	50.80
	(b) Hirakud	1.53	—	12.60	12.60	100	25.20
			12000	13.00	13.00	100	26.00
	(c) Maithon	1.5	12000	20.80	20.80	100	41.6
			12000	20.80	20.80	100	41.6
	(d) Panchet Hill	2.5	12000	20.80	20.80	100	41.6
			12000	20.80	20.80	100	41.6
4.	*3/4 Cyds. Shovel*						
	Bhakra	1.1	17000	6.20	13.94	225	20.14
			10000	10.50	10.50	100	21.00

TABLE 16.6.1. (*ii*)

Fuel & Lubricants etc. and Labour Charges of Shovels

N.B.—The bottom figures in each line are on the basis of Rates & Costs Committee recommendations.

Sl. No.	Equipment/Project	Fuel & Lubricants etc. HSD oil gls./hr.	Fuel & Lubricants etc. Total Amount (Rs.)	Labour per hr.	Total (4 & 5)
1	2	3	4	5	6
1.	3½ *Cyds. Shovel*				
	(a) Bhakra	6.00	16.12	4.31	20.43
		5.5	11.25	1.80	13.05
	(b) Hirakud	4.00	8.35	2.25	10.60
		5.5	11.25	1.80	13.05
2.	2½ *Cyds. Shovel*				
	(a) Bhakra	5.82	15.10	2.25	17.35
		5.00	10.6	1.80	12.3
	(b) Nangal	5.00	11.50	4.81	16.31
		5.00	10.5	1.8	12.3
	(c) Hirakud	4.00	8.82	1.99	10.81
		5.00	10.50	1.80	12.3
	(d) Maithon	7.50	15.00	2.64	17.64
		5.00	10.50	1.80	12.3
	(e) Panchet Hill	8.10	20.20	—	—
		5.00	10.50		
3.	1½ *Cyds. Shovel*				
	(a) Bhakra	3.00	10.50	3.38	13.88
		4.00	9.00	1.80	10.8
	(b) Hirakud	4.00	8.37	1.91	10.78
		4.00	9.0	1.80	10.8
	(c) Maithon	4.25	10.00	—	—
		4.00	9.00	1.80	10.8
	(d) Panchet Hill	4.50	6.20	—	—
		4.00	9.00		
4.	*Cyds. Shovel*				
	Bhakra	1.75	7.12	3.40	10.52
		2.00	5.25	1.80	7.05

16.6.2. The above tables will show that:—

Bhakra :—It has assumed excessive figures for the life of the equipment, giving low figures for depreciation. Their figures for repairs are again on the high side but the two together tally closely with our recommendations.

The labour charges there, are rather high and can be explained partly by the difficult terrain, and partly by the 3 shift working, which is uneconomical for shovel operations. Their expenditure on fuel and lubricants is also on the high side and requires looking into.

Nangal :—Life assumed is excessive. The rate of depreciation is low. Labour charges are high. Expenditure on P.O.L. on $2\frac{1}{2}$ and $3\frac{1}{2}$ Cyds. shovel are on the low side and need attention.

Maithon :—Life assumed is nearly correct, so is the provision for repairs and overhaul. Their expenditure on labour is 50% higher than justified and is that under P.O.L. The corresponding figures for production are low, indicating a serious state of affairs.

Panchet Hill :—The position here is similar to that at Maithon as regards the use rates. Figures for production are not available and no comments can, therefore, be given.

Harike :—The life assumed is 60% higher as usual and the figures for expenditure on labour and P.O.L. figures for repairs are reasonable. Figures for production are satisfactory.

16.7. DRAGLINES.

16.7.1. Table 16.7.1. (*i*) gives the life rate and depreciation allowance for repairs. Table 16.7.1. (*ii*) gives figures for expenditure under labour and P.O.L.

16.7.2. Comments

It willl be seen that :—

Maithon :—The life assumed is 50% higher than ours while the figures for repair are 25% higher. Data for labour and P.O.L. are not available, nor are the figures for productivity.

Sarda Hydel :—The life assumed is nearly correct, but the provision for repairs is rather low, for charges labour are high. Expenditure on P.O.L. is on the low side. Their output is reasonable.

TABLE 16.7.1. (*i*)

Life, Depreciation & Repairs of Draglines

Sl. No.	Equipment/ Project	Cost in lakhs	Life in hours	Deprecia-tion per hour.	Repairs (major & minor)	Percentage repair over Depreciation	Total Dep. & repairs per hr.
1	2	3	4	5	6	7	8
1.	3½ *Cyds. Shovel*						
	Tungabhadra (Andhra)	3.7	24000	15.53	3.90	25	19.43
			15000	24.92	19.94	80	44.86
2.	2½ *Cyds. Shovel*						
	(a) Harike	3.2	24000	13.30	13.94	105	27.84
			15000	21.20	16.96	80	38.16
	(b) Sarda Hydel	2.6	14000	19.75	9.90	50	29.65
			15000	18.40	14.72	80	33.12
	(c) Tungabhadra (Andhra)	2.8	1800	15.75	3.95	25%	19.80
			15000	19.00	15.20	80	34.2
	(d) Tungabhdra (Hyderabad)	2.2	28800	5.41	6.49	120	11.90
			15000	10.40	12.4	80	18.72
3.	½ *Cyds. Shovel*						
	(a) Tungabhadra (Andhra)	1.9	18000	10.37	2.59	25	12.95
			12000	15.50	12.4	80	27.9
	(b) Maithon	2.4	18000	10.10	10.10	100	20.20
			12000	15.00	12.0	80	27.0
4.	¾ *Cyds. Shovel*						
	(a) Harike	1.1	16090	6.68	5.63	84	12.31
			10000	10.07	8.06	80	18.13
	(b) Lower Bhawani	1.1	10000	10.88	1.06	9.75	11.94
			10000	10.88	8.70	80	19.58
	(c) Tungabhadra	1.3	10000	13.15	3.29	25	16.44
			10000	13.15	10.52	80	23.67

TABLE 16.7.1.(*ii*)

Fuel & Lubricants etc. and Labour of Draglines

Sl. No.	Equipment/Project	Fuel & Lubricants etc.		Labour per hour	Total (4 & 5)
		HSD oil gls./hr.	Total amount Rs.		
1	2	3	4	5	6
1.	$3\frac{1}{2}$ *Cyds. Shovel*				
	Tungabhadra (Andhra)	—	7.81	2.92	10.74
		5.5	11.25	1.80	13.05
2.	$2\frac{1}{2}$ *Cyds. Shovel*				
	(a) Harike	7.0	14.00	6.38	20.38
		8.0	10.50	1.80	12.30
	(b) Sarda Hydel	—	8.5	3.00	11.50
			10.50	1.80	12.30
	(c) Tungabhadra (Andhra)	2.4	4.63	1.00	5.63
		5.0	10.50	1.80	12.30
	(d) Tungabhadra (Hyderabad)		16.22	1.88	18.10
			10.50	1.80	12.30
3.	$1\frac{1}{2}$ *Cyds. Shovel*				
	Tungabhdra (Andhra)	2.5	6.16	2.44	8.60
		4.0	9.0	1.80	10.80
4.	$\frac{3}{4}$ *Cyds. Shovel*				
	(a) Harike	2.0	5.50	3.56	9.06
		2.0	5.25	1.80	7.05
	(b) Lower Bhawani	1.1	2.00	1.38	3.38
		2.0	5.25	1.80	7.05

Tungabhadra (*Andhra*) :—The life assumed is 60% higher for $3\frac{1}{2}$ cu. yds., 20% for $2\frac{1}{2}$ cu. yds. 50% for $1\frac{1}{2}$ cu. yds. and is at far for $\frac{3}{4}$ cu. yds. shovel than the figures recommended by us. Provision for repairs and overhaul is very much on the low side, indirectly that the equipment has been used sparingly.

Expenditure under labour and P.O.L. is low. Productivity is above the average.

Tungabhadra (*Hyd.*) :—Life assumed is nearly double of our recommendation. Provision for repairs and overhaul is 50% higher than ours. Labour is at par, while expenditure and P.O.L. is 60% higher. Figures for productivity are not available.

16.8. Tractor Dozer

Lower Bhawani :—Life adopted tallies with our figures. Provision for repairs is exceedingly low and so are the figures for expenditure under labour and P.O.L. Production figures are not available.

Table 16.8.1. (*i*) gives figures for life depreciation, repairs and overhaul, while Table 16.8.1. (*ii*) gives figures for expenditure on labour and P.O.L. The following is the analysis by Projects :—

TABLE 16.8.1 (*i*)

Depreciation and repairs of tractor dozer

N. B. The bottom figures in each line are on the basis of R.C.C. recommendations regarding life & percentage of repairs & maintenance.

Sl. No.	Equipment/ Project	Cost in lakhs	Life in hours	Depreciation per hour	Repairs, (major & minor)	Percentage of repairs over depreciation	Total depreciation & repairs
1.	175 *H.P.*						
	(a) Bhakra	1.4	12000	11.75	32.31	275	44.06
			12000	11.75	11.75	100	23.50
	(b) Harike	0.9	10000	9.41	5.52	60	14.93
			12000	11.75	11.75	100	23.50
	(c) Maithon	1.0	8000	13.25	13.25	100	27.5
			12000	8.83	8.83	100	17.66
	(d) Panchet Hill	1.28	8000	16	16	100	32
			12000	10.7	10.7	100	21.4
	(e) Gangapur	1.2	10000	12.09	10.3	85	22.39
			12000	10.08	10.08	100	70.16
	(f) Kakrapar	0.99	10000	9.9	9.9	225	30.07
			12000	8.35	8.35	100	18.50
2.	130 *H.P.*						
	(a) Bhakra	1.1	12000	9.25	20.82	225	30.07
			12000	9.25	9.25	100	18.50
	(b) Nangal	1.2	10000	10.0	8.0	80	18.0
			12000	10.0	10.0	100	20.0
	(c) Harike	1.0	10000	9.61	5.88	60	15.49
			12000	8.0	8.0	100	16.00

TABLE 16.8.1. (*i*)—contd.

Depreciation and repairs of tractor dozer

N.B. The bottom figures in each line are on the basis of R.C.C. recommendations regarding, life, percentage of repairs & maintenance.

Sl. No.	Equipment/ Project	Cost in lakhs	Life in hours	Deprecia-tion per hour	Repairs (major & minor)	Percentage of repairs over dep-reciation	Total deprecia-tion & repairs
	(d) Hirakud	0.8	7000	11.53	11.53	100	23.06
			12000	6.7	6.7	100	13.4
	(e) Gangapur	0.8	10000	7.5	10.3	137.5	17.8
			12000	6.25	6.25	100	12.5
	(f) Tungabhadra (Hyd.)	0.8	28800	2.86	3.44	120	6.30
			12000	6.85	6.85	100	13.70
3.	120 *H.P.*						
	(a) Maithon	0.7	8000	11.5	11.5	100	23.0
			12000	7.65	7.65	100	15.3
	(b) Hirakud	0.9	7000	12.85	12.85	100	25.7
			12000	7.5	7.5	100	15.0
	(c) Lower Bhawani.	0.5	10000	4.44	3.44	77.5	7.82
			12000	3.70	3.70	100	7.40
4.	81 *H.P.*						
	(a) Bhakra	0.8	12000	6.5	14.63	225	21.13
			10000	7.8	7.8	100	15.6
	(b) Nangal	0.3	10000	3.3	2.5	75	5.8
			10000	3.3	3.3	100	6.6
	(c) Harike	0.4	10000	3.82	2.56	67	6.38
			10000	3.82	3.82	100	7.64
	(d) Sarda Hydel	0.8	8000	10.0	10.0	100	20.0
			10000	8.0	8.0	100	16.0